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Data sheet

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Abstract: There is an increasing interest for mineral and hydrocarbon exploration in Greenland and in both regards the Nuussuaq peninsula is in focus. This preliminary strategic environmental impact assessment describes the status of the biological knowledge from the area and designates potential conflicts between activities and the biological environment. Furthermore biological knowledge gaps are identified. These should be filled before specific environmental impacts assessments can be carried out and relevant studies to fill these data gaps are proposed.

Keywords: Strategic environmental impact assessment, mineral exploration, mining, hydrocarbon exploration, petroleum exploitation, Greenland, Nuussuaq peninsula

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Preface

There is an increasing interest in mineral as well as hydrocarbon exploration in Greenland and the Nuussuaq peninsula is in focus with regard to both activities. The Bureau of Minerals and Petroleum, Greenland Home Rule, therefore requested a preliminary strategic environmental impact assessment of mineral and hydrocarbon activities in this area from the National Environmental Research Institute, Denmark.

Summary

There is an increasing interest in mineral and hydrocarbon exploration in Greenland and the Nuussuaq peninsula is in focus with regard to both activities. In 1996, an oil exploration well was drilled, and a company is currently engaged in exploration for nickel. However, before more activities are initiated, the Bureau of Minerals and Petroleum (BMP), Greenland Home Rule, has requested a strategic environmental impact assessment with regard both to mineral and petroleum activities in the area.

Impacts from mineral and hydrocarbon activities mainly include:

Common to mineral and hydrocarbon activities

- disturbance of wildlife
- visual impacts
- damage to vegetation and terrain
- waste water release
- release of drilling substances
- emissions to air.

Impacts from mineral activities

- deposition of waste rock and tailings
- risk of dust contamination

Impacts from hydrocarbon activities

- seismic surveys
- release of produced water
- chronic oil contamination
- risk of acute oil spill.

There is a high risk of conflict between activities and environmental issues on the Nuussuaq peninsula, because the lowlands are restricted mainly to narrow coastal fringes and a few long and wide valleys. In these lowlands most of the mammals, birds and continuous vegetation are found, and the lowlands will most likely be used at least as transport corridors and probably also for exploration activities.

Valued ecosystem components (VECs) of the Nuussuaq peninsula include:

- the caribou population (small, isolated and red-listed as 'Vulnerable')
- the Greenland white-fronted goose (declining and small population, red-listed as 'Endangered')
- other birds: gyr falcon, great northern diver (common loon), common eider, harlequin duck, kittiwake and Arctic tern
- important habitats for these species
- seabird breeding colonies along the coasts
- Arctic char and the rivers where they spawn and winter
- rare plants and their habitats
- areas with particularly vigorous/luxuriant vegetation.

There is, however, a lack of biological information from the area, and the missing data should be obtained before specific EIAs are carried out.

A preliminary impact assessment of mineral and hydrocarbon activities in the area points to the risk of:

- negative effects on populations of caribou and the Greenland white-fronted goose
- negative effects on seabird breeding colonies
- negative effects on rare plants
- large-scale visual impacts on landscapes
- chemical pollution particularly from tailings and waste rock
- oil pollution from produced water
- oil spills
- large emissions of greenhouse gasses.

Modern technical solutions, including Best Available technology (BAT) and Best Environmental Practice (BEP), combined with strict regulation in order to avoid activities in sensitive areas and sensitive periods can in most cases mitigate and minimise impacts to acceptable levels.

Activities carried out by the local population, such as fishing and hunting, take place mainly in the coastal areas. Resources occurring here, such as capelin and Arctic char, are at risk of being be impacted by oil spills, and spawning stocks of Arctic char may be impacted if their passways are obstructed. Inland activities mainly include caribou hunting, which may be reduced or even stopped if the caribou population is reduced as a consequence of mineral or hydrocarbon activities.

Pollution from activities on land will usually be of a local or regional extent. Even an oil spill will be rather limited in distribution as long as it occurs on land. If an oil spill reaches the marine environment, e.g. transported by rivers, there is a risk of more extensive and widespread impacts.

Emission to the atmosphere may in the case of greenhouse gasses have global impacts and particularly a large oil field will have the potential to double the current Greenland contribution of carbondioxide. Arctic haze is also an issue to be aware of in case of large scale activities, particularly in the valleys of the peninsula.

Studies to be carried out as soon as possible:

- an aerial survey of Greenland white-fronted geese in July
- mapping of calving grounds and migration routes of the caribou population
- ground truthing of existing satellite images of vegetation types
- a general survey of fauna and flora in combination with the other studies.

Other studies to be carried out before extensive activities are initiated:

- background mapping of chemicals in the environment
- a survey of bathymetry and benthos of the surrounding waters in case of marine deposition of tailings
- a survey of seabird breeding colonies
- mapping of rare plants and their habitats.

Dansk resumé

Nuussuaqhalvøen i Vestgrønland er interessant både for mineral- og olieefterforskning. En olieboring blev gennemført i 1996 og et selskab leder efter nikkel i disse år. Inden der kommer flere aktiviteter i området har Råstofdirektoratet under Grønlands Hjemmestyre ønsket en strategisk miljøvurdering af de aktiviteter både eftersøgning og udnyttelse medfører.

Råstofaktiviteter medfører:

- operationer i terrænet (kørsel, helikopterflyvning, etc.),
- placering af infrastruktur (bygninger, veje, deponier, etc.),
- udledninger til vand og luft,
- risiko for uheld (især oliespild).

Disse aktiviteter medfører en lang række mulige påvirkninger, hvoraf de vigtigste er:

Fælles for mineral- og olieaktiviteter:

- forstyrrelser af dyreliv,
- visuelle påvirkninger af landskaber,
- skader på vegetation og terræn,
- spildevand,
- udledninger fra boreoperationer,
- udledninger til luften.

Særligt for mineralaktiviteter:

- deponering af mineaffald som "tailings" og gråbjerg med risiko for forurening,
- risiko for støvforurening fra transport af knuste mineraler.

Særligt for olieaktiviteter:

- seismiske undersøgelser,
- dannelse af produktionsvand,
- kronisk olieforurening,
- risiko for akutte oliespild.

Konfliktpotentialet mellem råstofaktiviteter og miljøet er stort på Nuussuaqhalvøen, fordi lavlandsområderne er meget begrænsede. De udgør smalle bræmmer langs kysten og nogle få brede dale, der går langt ind i indlandet. Det er primært her at dyr og sammenhængende vegetationen findes. Det er også her at det er lettest at komme til at arbejde med råstofefterforskning, og ved aktiviteter i højlandet vil dalene fungere som adgangsveje ud til kysten.

Særligt værdifulde økologiske elementer (en oversættelse af det canadiske begreb Valued Ecological Components) i området omfatter:

- den lille isolerede bestand af rensdyr,
- bestanden af grønlandsk blisgås,
- fuglearterne: jagtfalk, islom, ederfugl, strømand, ride og havterne,
- de vigtigste levesteder for disse arter,
- ynglekolonierne af havfugle langs kysterne, særligt Naajaat ved Qeqertaq,
- fjeldørred og deres opgangselve,
- sjældne planter og deres voksesteder,
- særligt frodige områder.

Der er dog væsentlige mangler i den foreliggende biologiske viden; mangler der bør udbedres for at der kan foretages egentlige miljøvurderinger af specifikke aktiviteter.

En foreløbig miljøvurdering af råstofaktiviteter i området angiver at der er risiko for:

- effekter på bestandene af rensdyr og grønlandsk blisgås,
- effekter på havfuglekolonierne,
- store visuelle skader på landskaber – visse områder er allerede påvirket,
- påvirkninger af bestande af sjældne planter,
- kemisk forurening, særligt fra deponier af "tailings" og gråbjerg,
- olieforurening m.m. fra produktionsvand,
- oliespild.

Desuden forventes det, at der ved etablering af et stort oliefelt vil blive udledt store mængder af drivhusgasser, som bidrager til drivhuseffekten og som også kan give lokale og regionale påvirkninger f.eks. i form af arktisk dis.

Moderne tekniske løsninger (BAT = Best Available Technology, BEP = Best Environmental Practice) i kombination med regulering med udgangspunkt i udpegning af særligt følsomme områder og perioder, vil i mange tilfælde kunne begrænse miljøpåvirkningerne.

Fangst og fiskeri foregår generelt langs kysterne, og kun rensdyr jages i indlandet. De kystnære fiskeressourcer så som lodde og fjeldørred kan påvirkes af oliespild, der når herud via vandløb, og ørredbestandene kan påvirkes, hvis deres gyde og vinteropholdssteder i elvene afspærres. Rensdyrjagten kan blive påvirket, hvis bestanden reduceres som følge af aktiviteter. For eksempel kan jagten blive begrænset eller stoppet for at fremme vækst i en reduceret bestand.

Generelt vil forurening fra aktiviteter på land blive af lokalt og regionalt omfang. Selv et oliespild vil, hvis det ikke kommer ud i det marine miljø, blive begrænset i udbredelse. En undtagelse er luftforureningen, hvor især udstødningen fra maskineri kan blive af meget stort omfang afhængigt af aktiviteternes størrelse. Store marine oliefelter i Norge udleder dobbelt så meget CO_2 som Grønlands samlede bidrag i dag.

Det foreslås at følgende undersøgelser bliver gennemført snarest:

- Grønlandsk blisgås: optælling fra fly af fældende fugle i hele området, inkl. den østlige del, som ikke er blevet undersøgt før.

- Rensdyr: Kortlægning af kælveområder, andre vigtige områder og migrationsruter ved hjælp af satellitsporing.
- Vegetation: Verifikation i felten af vegetationstyper identificeret med satellit.
- Fauna og flora: Generel eftersøgning i kombination med ovenstående.

Undersøgelser der bør gøres inden større aktiviteter indledes:

- Baggrundsundersøgelser af kemiske forhold.
- Optælling og kortlægning af havfuglekolonier langs kysterne.
- En mere præcis kortlægning af sjældne planters og dyrs forekomst.
- Undersøgelse af dybde- og bundforhold, i tilfælde af at der påtænkes marin deponering af ”tailings”.

Naalisagaq kalaallisut

Kitaani Nuussuaq aatsitassarsiornikkut uuliasiornikkullu soqutiginartuuvoq. 1996-imi ulliasiorluni qillerisoqarpoq ingerlatsivimmillu ukiuni tamakkunani nikkilisiortoqarluni. Ingerlatanik taamaattunik amerlanerusunik pisoqalersinnagu Namminersornerullutik Oqartussat ataanniittoq Aatsitassarsiornermut Ikummatissarsiornermullu Pisortaqarfiup ingerlatsinerit taamaattut ujarlernerillu nassatarisinnaasaannik siumut isigisumik avatangiisinik tunngatillugu misissuisoqarnissaa kissaatigisimavaa.

Aatsitassarsiornerup nassatarisarpai:

- Nunami sulianik assigiinngitsunik ingerlatsineq (qamutinik motorilinnik angallanneq, helikopterimik timminerit il.il.),
- Angallannermut atortulersuineq (illut, aqqusernit katersukkanik toqqortuiffiit, il.il.),
- Imermik kuutitsineq silaannarmillu aniatitsineq,
- Ajutoornissamik aarlerinartorsiortitsineq (pingaartumik uuliamik maangaannaq kuuttitsisoorneq).

Ingerlatat tamakkua assigiinngitsorpassuarnik sunniuteqarfeqarsinnaapput, makkuali pingaarnerusut tassaapput:

Aatsitassarsiornermut ulliasiornermullu ataatsimut tunngatillugu makkuupput:

- Uumasunik akornusersuineq,
- Nunap pissusiinik takussaasunik sunniuteqarneq,
- Naasunik nunamillu ajoqusiinerit,
- Imikoorneq,
- Qillerinermut atatillugu kuutitsinerit,
- Silaannarmut aniatitsinerit.

Pinmgaartumik aatsitassarsiornermut tunngatinnerullugu:

- Piiaanerup perlukuinik katersukkat,"tailings"-itut ittut ujaqqallu sequnnerit qaleriissaakkat mingutitsilersinnaasut,
- Mineralinik sequtsikkanik assartuinermi pujoralatitsinikkut mingutitsinissap aarlerinaataa.

Pingaartumik uuliasiornermut tunngatinnerullugu:

- Nunamik sajuppillatitsisarluni misissuinerit,
- Imermik tunisassiornermut atugassamik pilersitsineq,
- Uuliakoorluni mingutitsiualerneq,
- Uuliamik aniasoortitseriataarnissap aalerinartua.

Aatsitassarsionikkut ingerlatsinerup tamaanilu avatangiisit imminnut aoortuutilersinnaanerat aaralerinartorujussuuvoq, tassami tamaani toqqinnersat pukitsumiittut killeqaqimmata. Ilaatigut tamakkua sinerissamiipput ippikillutik ilaatigullu qooqquni silittuni tnunap timaanut pavungarsuaq atasuni illutik. Tassaluuna uumasut naasoqarfiillu ataqatigiit annertunerusumik tamaani naapitassaasut. Amerlanertigullumiuna aamma tamakkunani aatsitassarsiorluni sulinissaq ajornanginnerusartoq, aammalumi qatsinnerusumi arlaannik ingerlatsissagaanni qooqqut tassaallutik sinerissap tungaanut aqquteqarfiusariaqartut.

Uumasoqarnikkut immikkut pingaarutillit (canadamiut oqariartaasiat Valued Ecological Components nutsiinnarlugu) taaneqarsinnaasut tamaaniittut makkuupput:

- Tuttoqatigiit ikittunnguit immikkuuillutik tamaani uumasuusut
- Kalaallit nerlernaat tamaani uumasuusut,
- Timmissat: kiisaviarsuit, tuulliit, mitit, toornaviarsuit, taateraat imeqqutaallallut,
- Taagorneqartut taagorneqartut najortagaasa pingaarnersaat,
- Sinerissami timmissat imarmiut piaqqiorfii, pingaartumik Naajaani Qeqertamilu,
- Eqaluit kuuillu taakkua majortagaat,
- Naasut qaqutigoortut tamakkualu naasarfii,
- Nunap ilai naggorilluinnartut.

Biologimulli tunngatillugu ilisimasat pigineqartut pingaarutilinnik amigaateqarput; amigaatit ingerlatanut aalajangersunut tunngatillugu avatangiisinik nalilersuinivimmik ingerlatsisoqarsinnaassappat pitsaanngorsarneqartariaqartut.

Aatsitassarsiorluni tamaani ingerlatanik utaqqiisaagallartumik avatangiisinut tunngatillugu naliliinerup aarlerigisariaqarsorai:

- Ingerlatat tamakkua tuttoqatigiinnut kalaallillu nerlernaannut tamaaniittunut sunniutissaat,
- Timmissat imarmiut erniorfiinut sunniutissaat,
- Tamaani nunap ilusaanik takussaasunik annertuumik aseruinissaq – ilaatigummi tamatuma ilaa sunnerneqareersimavoq,
- Naasunik qaqutigoortunik tamakkualu naasarfiinik sunniinissaq,
- Kemisk-imik mingutitsineq, pingaartumik ”tailings”-inik ujaqqanillu piiarnerlukunik katersuiffinniit,
- Uuliakoorluni il.il., soorlu imeq tunisassiornermik atorneqartoq aqqutigalugu, mingutitsineq,
- Uuliamik aniasoorluni mingutitsineq.

Ilimagineqaraportaaq uuliasiorferujussuarmik pilersitsisoqarneratigut annertoorujussuarmik kissattoornerup gassiinik aniatitsineqalerumaartoq kissattornermut ilapittuutaasumik aammalu tamaanga nunallu ilaanut sunniuteqartumik, soorlu issittup iserianneranik pilersitsineratigut.

Nutaaliamik teknikikkut aaqqiissutit (BAT = Best Available Technology, BEP = Best Environmental Practice) nunap ilaanik ukiullu ilaanik eqqornerlukkuminartunik toqqaalluni killilersuinermik peqatilerlugit amerlasuutigut avatangiisinik sunniinernik killilersimaarisinnaapput.

Piniarneq aalisarnerlu nalinginnaasunik sineriaq atuarlugu ingerlanneqartarput, taamaallaat tuttut nunap timaani piniarneqartarlutik. Sinerissap qanittuani aalisakka isumalluutit, soorlu ammassat eqaluillu uuliaarluernermit, tamaanga kuuit aqqutigalugit annguttumit, eqaluillumi aamma sunnerneqarsinnaapput, suffisarfitik ukiisarfitillu asserneqarpata. Tuttunniarneq sunnerneqarsinnaavoq ingerlatat pissutaallutik tamatuma tuttui ikilisinneqassagaluarpata. Tuttunniartarnemi killilersorneqalersinnaavoqunitsivinneqarsinnaalluniluunniit tuttut ikilisimasut amerliartoqqilernissaat siunertaralugu.

Ataatsimut isigalugit nunami ingerlatsinikkut mingutitsineq tamaanga nunallu ilaanut tamaanga tunnganerussaaq. Tamaanimi uuliaarluernerluunneq, immamut avalanngikkuni killilersimaarneqarsinnaassaaq. Silaannakkulli minguitsineq taamaanngilaq, pingaartumimmi maskinat ingerlaneratigut aniatinneqartuuguni, ingerlatat annertussusiat apeqqutaalluni annertoorujussuusinnaagami. Norge-p imaannarmi uuliasiorfissui CO_2 -mik Kalaallit Nunaata tamarmiusumik ullumikkut aniatitaa marloriaataanik aniatitsipput.

Misissuinerit makkua piaarnerpaamik ingerlanneqarnissaat siunnersuutigineqarpoq:

- Kalaallit nerlernaat: isanerini timmisartumiit tamanna tamakkerlugu, kangisinnerusortaa siornatigut misissorneqarnikuunngitsoq, ilanngullugu kisitsineqassassoq.
- Tuttut: norrisarfii allallu pingaarutillit ingerlaartarfiilu nalunaarsorneqassasut qaammataasanut aallakaatitsissusersuinikkut malittarinnittarneq atorlu.
- Nunap naasoqarnera: Tamaani naasartut assigiinngitsut suuneri paasiniarlugillu aalajangersorneqassasut qaammataasat atorlugit.
- Uumasut naasullu: Nalinginnaasumik qulaani taagorneqartunut atatilluugu ujarlerneqassasoq.

Annertuunik ingerlatsisoqalersinnagu misissuinerit naammassineqarsimasariaqartut:

- Kemiskinut tunngatillugu pissutsinik tamakkua tamaani qanoq akuutigereernerinik misissuinerit.
- Sinerissami timmissanik ineqarfimminniittunik ineqarfiinillu kisitsineq nalunaarsuinerlu.
- Naasut uumasullu qaqutigoornerusut qanoq amerlatiginerinik suminnerinillu eeqqornerusumik nalunaarsuineq.
- ”Tailings”-inik immamut pikoornissaamik eqqarsaateqartoqarpat immap itissutsiinik imallu naqqata qanoq innerinik misissuineq.

1 Introduction

This report is a preliminary strategic environmental impact assessment (SEA) of mineral and petroleum activities on the Nuussuaq peninsula in West Greenland. The area has both a hydrocarbon and a mineral potential, and exploration activities for these resources are expected to increase in the coming years.

The assessment is preliminary, because it is based solely on existing information. One of the main objectives has been to identify important data gaps which should be filled in order to prepare a more elaborate strategic impact assessment or future environmental impact assessments of specific activities. However, a new analysis of remotely sensed data on vegetation is presented.

The impact assessment encompasses only biological resources, chemical background measurements and local use of the area. Socioeconomics, archaeology and cultural history are not included.

The preparation of this assessment was supported financially by Bureau of Minerals and Petroleum, Greenland Home Rule.

It is important to stress that an SEA does not replace the need for site- and activity-specific Environmental Impact Assessments (EIAs). The SEA provides an overview of the environment in the licence area as well as in adjacent areas which can be impacted by the activities. It identifies major potential environmental effects associated with expected offshore oil and gas activities. The SEA will also identify knowledge and data gaps, highlight issues of concern, and make recommendations for mitigation and planning. An SEA is included in the background for the decisions made by the relevant authorities, and may identify general regulatory or mitigative measures and monitoring requirements that must be dealt with by the companies applying for concessions.

Abbreviations used

AMAP = Arctic Monitoring and Assessment Programme
a.s.l. = above sea limit
BAT = Best Available Technology
BEP = Best Environmental Practice
EIA = Environmental Impact Assessment
NERI = National Environmental Research Institute, Denmark
GEUS = Geological Survey of Denmark and Greenland
GINR = Greenland Institute of Natural Resources
PAH = Polycyclic Aromatic Hydrocarbons
SEA = Strategic Environmental Impact Assessment
VEC = Valued Ecosystem Components
VOC = Volatile Organic Components).

1.1 The assessment area

The area described in this report is the entire Nuussuaq peninsula, delimited to the east by the Ice Cap: Store Gletscher and Sermeq Avannerleq (Figure 1). The immediate inshore waters are included in the assessment, but the waters outside this zone are generally excluded. However, marine waters may be impacted by accidental oils spills from transport of oil from land-based wells. Also, deposition of tailings and waste rock may take place in the sea, which, for example, was the case at the zinc and lead mine in Maarmorilik in Uummannaq Municipalicity (Asmund & Johansen 1999). The waters surrounding the peninsula are the strait of Vaigat to the south and Uummannaq Fjord and Qarajaqs Isfjord to the north (Figure 1).

Only three small settlements are situated on the peninsula: Saqqaq (183), Niaqornat (69) and Qaarsut (195). However, the town of Uummannaq (1322) and the settlements Qeqertaq (163) and Ikerasak (279) are very close to the assessment area (Figure 1). Numbers in brackets indicate the number of people per 1 January 2006 (Grønlands Statistik 2006). An air strip is situated in Qaarsut and it functions as the airport for Uummannaq town. The peninsula is divided between two municipalities: Uummannaq to the north and west and Ilulissat to the south (Figure 1).

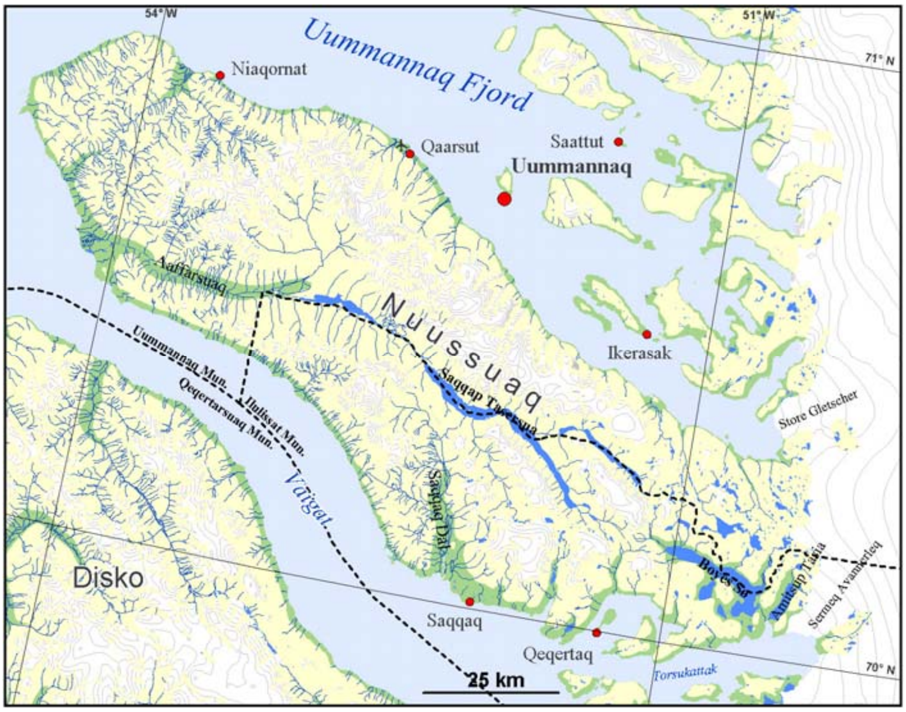


Figure 1. Nuussuaq peninsula and adjacent areas. Red dots are towns and settlements, hatched lines are municipality borders. Green indicates lowland below 200 m a.s.l. and white glaciers and the Inland Ice.

2 Potential hydrocarbon and mineral activities in the area

The Nuussuaq peninsula has potential in relation both to hydrocarbon and mineral activities. Oil seeps are known from the coastal areas of the western part. A Canadian company carried out several slim core drillings and one full-scale oil exploration drilling in the early 1990s. Another Canadian company is currently searching for nickel in the central part of the peninsula.

Activities common to exploration and exploitation for both hydrocarbons and minerals include establishment of infrastructure, vehicle and helicopter traffic, drilling operations, release of combustion gases from heavy machinery (greenhouse gasses), etc. As most transport of heavy equipment will take place by ship, sailing is also a common activity. Environmental impacts related to these activities are visual (infrastructure placed within the landscape, ruts and tracks in terrain and vegetation). They also involve disturbance to wildlife, including destruction of habitats by placement of infrastructure in the landscape ('footprint'), as well as climate change, and the release of chemicals and cuttings from drilling operations, in addition to release of waste from camps, etc.

Specific mineral activities include transportation of ore, deposition of tailings and waste rock. These activities may impact the environment by heavy metal pollution both in the aquatic and terrestrial environments (via dust). Other substances, e.g. from the production of concentrate (e.g. cyanide, flocculants), may also pollute the environment. And tailings and waste rock depots may occupy large areas. Open-pit mining creates scars in the landscape.

Specific hydrocarbon activities include seismic surveys and discharge of production water as well as the flaring of gas. Environmental impacts related to these activities can be disturbance to wildlife, pollution with heavy metals and other chemical substances, release of greenhouse gasses, etc, as well as chronic oil pollution. However, the most serious potential impacts are related to accidental oil spills, either from the well (blow-outs) or from wrecks during transport. Particularly oils spills in coastal waters have the potential to cause far-ranging environmental impacts. See Table 1 and Table 2.

Table 1. Overview of geographical extent and biological level of environmental impacts (nature) of mineral and hydrocarbon activities. L = local impacts (only measurable in the near surroundings), R = regional impacts (can be traced in more extensive areas such as a countywide, fjord/valley systems, etc., I = individual level, P = population level, E = ecosystem level.

Mining activities

Impacts	Terrain and vegetation	Disturbance of wildlife	Visual
Prospecting	L	L – I	L/R*
Exploration	L	L/R** - I/P**	L
Exploitation	L	L/R** - I/P**	L
Decommissioning	L	L - I	L

* regional in case of extensive driving
** regional in case of long transport corridors.

Hydrocarbon activities

Impacts	Terrain and vegetation	Disturbance of wildlife		Visual
		on land	at sea	
Prospecting	L	L – I	-	L
Seismic surveys	L/R	L/R – I/P**	L/R – I	L/R
Exploration drilling	L	L – I	L/R – I/P	L
Exploitation	L/R*	L/R* - I/P**	L/R – I/P	L/R*
Decommissioning	L	L – I	L – I	L
Oil spill	L	L – I	R – P/E	-

* regional in case of long transport corridors
** under certain circumstances at population level.

Table 2. Overview of geographical extent and biological level of environmental impacts of mineral and hydrocarbon activities (discharges to different compartments of the environment). L = local impacts (only measurable in the near surroundings), R = regional impacts (can be traced in more extensive areas such as county level, fjord systems, etc., G = global impacts, I = individual level, P = population level, E = ecosystem level.

Mining activities

Impacts	Chemical pollution	Physical	Discharges to the air
Prospecting	L	negligible	negligible
Exploration	L	negligible	negligible
Exploitation	L/R	L/R	G/R**
Decommissioning	L	L	negligible

* global in case of greenhouse gasses and regional in case of NO_x, if fossil fuels are used for energy production.

Hydrocarbon activities

Impacts	Chemical pollution	Physical	Discharges to the air
Prospecting	L	negligible	negligible
Exploration drilling	L	negligible	negligible
Exploitation	L/R	L/R	G/R**
Decommissioning	L	L	negligible
Oil spill	R		-

* deposition of cuttings, mud, tailings etc.
** global in case of greenhouse gasses and regional in case of NO_x, if fossil fuels are used for energy production

3 The physical environment

3.1 Topography

The Nuussuaq peninsula is about 175 km long and 50 km wide. It is dominated by alpine areas with the highest mountain tops reaching 2,144 m a.s.l. Lowlands are found in the coastal forelands and in the valleys. The most prominent valleys are the central Aaffarsuaq valley, the Saqqaq valley and the Boyes Lake valley. Many coastlines are steep with only narrow forelands, but wider, gently sloping forelands are found especially at the tip of the peninsula. Lakes are few in number, and large lakes are found only in the central valley and in the eastern part of the peninsula. The coasts are generally rocky or with narrow sediment beaches. Only in the mouth of the Aaffarsuaq valley is a small salt marsh found, behind a boulder beach. Extensive glaciers cover the highest parts of the area and turbid meltwater flows from these to the rivers and lakes of the central Aaffarsuaq valley, while the water in lakes in the eastern area appears to be clear. A special landscape feature – linked to the permafrost – is represented by the small distinct hills in the floor of the main valleys, the pingos (or mud vulcanoes).

3.2 Climate

The climate of the peninsula is Arctic with average July (the warmest month) temperatures below 5°C, indicating that it is within the High Arctic climate zone. The surrounding seas are usually ice-covered in the period December-May, although in recent years the extent of this period has been shorter and the ice conditions less heavy.

Currently, the information available on the snow cover and length of the growing season on Nuussuaq is limited. However, this will change within few month since the Danish Meteorological Institute is finishing a project that models climate in the entire of Greenland from 1950 to 2090 (http://klimagroenland.dmi.dk). This will enable a study of the length of the growing season and precipitation patterns for Nuussuaq not only during the present time, but also projected changes for the coming decades. The study has a resolution of 25 km by 25 km, which provides the possibility of looking at differences between the most western, coastal parts and the inland, eastern parts of the peninsula.

4 The biological environment

4.1 Birds

This section describes the birds occurring on the Nuussuaq peninsula; both those living inland (including birds in freshwater habitats) and those along the coasts, dependent on the marine environment.

Very few published sources deal specifically with the breeding birds of the area. The landbirds were described by Bertelsen (1921) and by Fencker in 1950, and finally Joensen & Preuss (1972) carried out systematic breeding bird surveys in 1965 in the Saqqaq valley. However, information on landbirds is also found in more general and synoptic works (Salomonsen 1960, 1967, Boertmann 1994).

The marine birds of the area also were described by Bertelsen (1921). He meticulously described and mapped all the seabird breeding colonies of the Uummannaq District (= Uummannaq Municipality), which includes the major part of the peninsula. In 1990, Burnham et al. (2005) revisited all these sites and described the population changes. The NERI seabird colony database holds information on all known seabird breeding colonies on the peninsula (Boertmann et al. 1996). The data in this database is of recent date (from the past 10 years) for many of the colonies.

The winter situation (in a mild winter) was described by Fencker (1947) and some aerial winter seabird surveys have in recent years included the westernmost parts of the peninsula (NERI, unpublished, Boertmann et al. 2004).

4.1.1 Landbirds (incl. birds in freshwater habitats)

The landbird fauna of West Greenland is relatively poor compared to other Arctic areas, and the Nuussuaq peninsula is no exception to this. The most important birds of the peninsula are the geese, and particularly the Greenland white-fronted goose (*Anser albifrons flavirsotris*). The geese arrive from wintering grounds in northwest Europe in early May and leave again in September. Breeding pairs occur scattered in the moist lowlands and seek to some degree to the same sites as the moulting birds after the eggs have hatched. A large segment of the population comprises non-breeding birds, which assemble in large flocks in marshes at lakes. Here they perform feather moult and become flightless for a three-week period in July. These birds are very sensitive to disturbance when flightless (Glahder & Walsh 2007, Madsen 2004).

Moulting geese in the Nuussuaq peninsula were surveyed from aircraft in July 1992, 1995 and 2003 (Glahder 1999, Glahder et al. 2002, Madsen 2004). Results are listed in Table 3.

Table 3. Results of aerial surveys for moulting geese in July 1992, 1995 and 2003 in Nuussuaq peninsula. In 1992 and 1995 a fixed-wing aircraft was used; in 2003 a helicopter. For details see Glahder (1999) and Madsen (2004). The figures include some breeding birds and chicks.

Species	1992	1995	2003
Greenland white-fronted goose	738	1002	281
Canada goose	0	166	558

The numbers recorded in 1992 and 1995 constitute a significant part of the entire population of the Greenland white-fronted goose (about 3% in 1995). The most important area for moulting geese – in the central Aaffarsuaq valley – was subsequently designated as an 'area important to wildlife' in the field rules for mineral exploration issued by BMP (BMP 2000, see https://arcims.mim.dk/website/DMU/AM/GL_Wildlife/viewer.htm). This area is shown in Figure 10. The population of Greenland white-fronted geese is small, numbering about 25,000 individuals in 2006, and has been decreasing since 1999, when the population peaked at approx. 35,000 individuals. The population is therefore particularly vulnerable (Fox et al. 2006), and is red-listed in Greenland as endangered (EN).

The decrease in the population may be related to the increase in the population of the Canada goose (*Branta canadensis*) (Fox et al. 2006). The Canada goose recently emigrated from Canada to Greenland (Boertmann 1994, Fox et al. 1996). The population is rapidly increasing and has been shown, at least in some situations, to have a competitive advantage over the white-fronted geese (Kristiansen & Jarret 2002). The Canada goose occurs primarily in the same kind of habitats as the Greenland white-fronted goose, and the general biology is similar for both, i.e. there is also a large segment of the Canada goose population which are non-breeders and which become flightless due to moult. The numbers of Canada geese recorded during the aerial surveys in 1992, 1995 and 2003 are shown in Table 3.

A third goose species occurs as a visitor during migration, both in spring and autumn. This is the light-bellied brent goose (*Branta bernicla hrota*) of the Northeast Canadian flyway population. These birds breed in High Arctic Canada, pass through and stage during migration in Greenland and Iceland, and winter in the British Isles. The population is small and numbers presently at in the region of 30,000 individuals (Colhoun et al. 2006). Particularly in autumn, brent geese may stage at low coasts and salt marshes, but no particularly important staging sites have been identified in the assessment area (Boertmann et al. 1997).

Some species of ducks occur in the inland areas, but none are numerous and particular areas of concentration are not known. Mallards (A*nas plathyrhynchos*) and red-breasted mergansers (*Mergus serrator*) breed at lakes and sheltered coasts and occur probably mainly in the easternmost part of the peninsula. Long-tailed ducks (*Clangula hyemalis*) also breed at lakes, ponds and protected coasts and are probably found in most of the lowlands of the peninsula. Finally, also harlequin duck (*Histrionicus histrionicus*) may breed in low numbers in inland areas. The breeding habitat for this species constitutes turbulent rivers and lakes with clear water. The only indication of breeding (not confirmed) was from a river on the northeast coast of the peninsula (Bertelsen 1920). The harlequin duck is redlisted as near threatened (NT) in Greenland due to the low number of breeding birds.

Two divers/loons breed in the area: the red-throated diver (*Gavia stellata*) breeds mainly at small ponds near the coast (Joensen & Preuss 1972). This species forages mainly in the marine environment, bringing food back to the chicks in the ponds. They are rather common where the habitat is present. The other species, the great northern diver/common loon (*Gavia immer*), breeds at large, deep lakes with clear water. Bertelsen (1920) considered it as a rare bird occurring in very small numbers in Uummannaq District. The large lake Boyes Sø and adjacent lakes may hold some pairs. The great northern diver is redlisted in Greenland as near threatened (NT) due to the low number of breeding birds.

Shorebirds are represented by purple sandpiber (*Calidris maritima*) and red-necked phalarope (*Phalaropus lobatus*). They occur in marshes with ponds and moist lowlands (Joensen & Preuss 1972). Great ringed plover (*Charadrius hiaticula*) may also breed in low numbers in the area.

Only two species of birds of prey breed in the area: Gyr falcon (*Falco rusticoulus*) and peregrine falcon (*Falco peregrinus*). Bertelsen (1920) described six breeding sites for gyr falcons in the Uummannaq part of the peninsula. These were however not used simultaneously and represented probably a small number of pairs. In 2000 Burnham et al. (2005) found only three of Bertelsen's 28 sites (in the entire Uummannaq district) occupied, but located an additional four. Joensen & Preuss (1972) reported a single pair from the Saqqaq Valley in 1965. With regard to peregrine falcons no information available for the area. However, the easternmost part of the peninsula resembles the preferred peregrine habitat in other parts of West Greenland and peregrines may potentially occur in this part of the assessment area. The gyr falcon is redlisted in Greenland as near threatened (NT) due to the low number of breeding birds.

In September 2007 a pair of white-tailed eagles (*Haliaeetus albicilla*) was observed at the Marrat area in the westernmost part of the peninsula. They were subadult birds, but apparently territorial, and may settle in this area.

Ptarmigan (*Lagopus mutus*) is common throughout the peninsula, avoiding only the highest alpine areas (Joensen & Preuss 1972).

Finally, five species of passerines commonly breed in the area (Joensen & Preuss 1972): raven (*Corvus corax*), northern weathear (*Oenanthe oenanthe*), redpoll (*Carduelis flammea*), lapland bunting (*Calcarius lapponicus*) and snow bunting (*Plectrophenax nivalis*).

4.1.2 Coastal birds

The breeding bird fauna along the coasts is dominated by the colonial species. These comprise: great cormorant (*Phalacrocorax carbo*), common eider (*Somateria mollissima*), glaucous gull (*Larus hyperboreus*), Iceland gull (*Larus glaucoides*), kittiwake (*Rissa tridactyla*), Arctic tern (*Sterna paradisaea*), razorbill (*Alca torda*) and black guillemot (*Cepphus grylle*). In total, 47 sites can be termed as seabird breeding colonies, i.e. sites (usually a steep cliff or a small, low island) holding at least five breeding pairs of the species. Several species often breed at the same site. Compared with other coasts in West Greenland the colonies along the Nuussuaq coast generally hold few birds. However, one very significant colony is found in the area: the Naajaat cliff a few kilometres southeast of the settlement Qeqertaq. At least 7,000 pairs of kittiwakes breed here (2006) in company with glaucous gulls and Iceland gulls, and it is one of the largest kittiwake colonies in West Greenland (Figure 2).

Overview of colonial species and their breeding abundance:

Great cormorant: 12 colonies all in the western part, and none exceeding 25 pairs.
Common eider: 5 breeding sites. One with 56 nests (in 2000) the other with max. 10 nests.
Iceland gull: at least 8 colonies, with up to 200 pairs, + one possible in the Torsukattaq fjord, only observed from great distance.
Glaucous gull: at least 16 colonies all small with max. 10 pairs.
Kittiwake: 2 colonies, one with min. 7,000 pairs (Naajaat) and one (probably not stable) with 20 pairs in 2000.

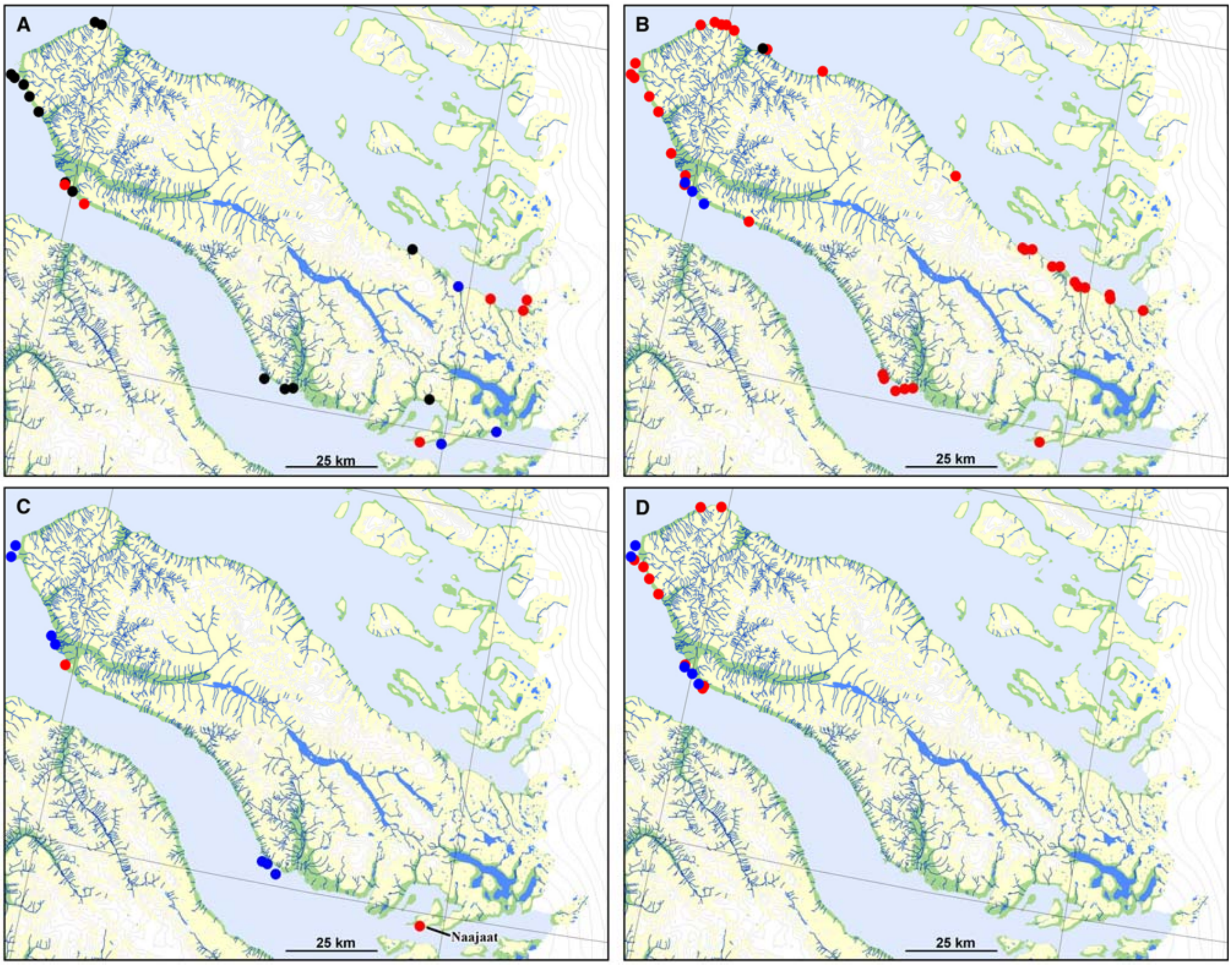


Figure 2. Distribution of seabird breeding colonies along the coast of the Nuussuaq peninsula. A gulls: red dots = Iceland gull, black dots = glaucous gull, blue dots = unidentified gulls (either Iceland, glaucous or both). B auks: red dots = black guillemot, blue dots = razorbill, black dot = Atlantic puffin. C kittiwake (red dots) and Arctic tern (blue dots). D common eider (blue dots) and great cormorant (red dots).

Arctic tern: 7 colonies, most on small islands, and with max. 200 pairs.
Razorbill: two colonies with max. 10 pairs in each, and an additional colony which has not been visited since 1920.
Black guillemot: at least 38 colonies, which each may hold up to 500 individuals.
Atlantic puffin (*Fratercula arctica*): only known from one site, where the species has not been recorded in many years.

Besides the colonial species, also solitary pairs of other seabird species breed along the coast. These are mainly great black-backed gulls (*Larus marinus*), Arctic skuas (*Stercorarius parasiticus*) and some of the ducks also breeding at lakes and ponds inland (red-breasted merganser and long-tailed duck).

Non-breeding individuals of some duck species assemble in flocks along the coasts to perform feather moult. These include common eider, king eider (*Somateria spectabilis*), long-tailed duck, red-breasted merganser and perhaps also harlequin ducks. In other parts of West Greenland significant non-breeding concentrations of these species occur. The coasts of Nuussuaq were surveyed in the years 1993, 1994 and 1995, mainly in search for moulting king eiders, and no significant concentrations (of any of the species) were located. Only in the archipelagos at the western tip of the peninsula were some flocks of common eider recorded.

Redlisted seabirds breeding on the Nuussuaq coasts include: common eider (vulnerable (VU) due to a decreasing population), kittiwake (vulnerable (VU), due to a decreasing population) and Arctic tern (near threatned (NT) due to a decreasing population).

4.1.3 Non-breeding season

There are very few landbirds present on the Nuussuaq peninsula in winter (December-February). Ptarmigans, gyr falcons, ravens and Arctic redpolls (*Carduelis hornemanni*) are the only species occurring, and they are present in low numbers and very dispersed.

Coastal birds may be present in the late winter in some concentrations at the western part of the peninsula when open waters occur, and these include mainly common and king eiders and gulls.

4.2 Mammals

The land mammal fauna of Nuussuaq peninsula is poor. Only Arctic fox (*Alopex lagopus*), Arctic hare (*Lepus arcticus*) and caribou (*Rangifer tarandus*) occur. The fox and the hare are common and widespread. The caribou population is small and isolated from the other populations in West Greenland. Feral reindeer was introduced in 1967 to strengthen the population. But the two kinds of caribou/reindeer are apparently separate and have different habits, with the feral population occupying mainly the eastern third of the peninsula and the native population mainly the middle third (Cuyler 2004). A survey in April 2002 resulted in approx. 1,200 observed animals, of which 1/3 were of the original population. Very few were observed in the western third of the peninsula in April

2002. Due to the small size of the original population it is included on the Greenland redlist as vulnerable (VU).

Marine mammals occurring in the waters near Nuussuaq peninsula include four species of seals, walrus (*Odobenus rosmarus*) as well as several species of whales. Polar bear (*Ursus maritimus*) is a rather rare winter visitor. In summer, the fin (*Balaenoptera physalus*), minke (*Balaenoptera acutorostrata*) and humpback (*Megaptera novaeangliae*) whales and the harp (*Phoca groenlandica*) and hooded (*Cystophora cristata*) seals are frequent and, in winter, walrus, narwhal (*Monodon monoceros*), white whale (*Delphinaptera leucas*) and bowhead whales (*Balaena mysticetus*) occur in the waters close to the Nuussuaq peninsula. However they are mainly found in offshore waters, and probably will not be impacted from land-based activities on the peninsula.

4.3 Fish

Only two fish species occur in the freshwaters of the area: Arctic char (*Salvelinus alpinus*) and three-spined stickleback (*Gasterosteus aculeatus*).

According to an interview study of local fishermen, Arctic char are found in five or six rivers of the peninsula, including the large river in central Nuussuaq (Olsvig & Mosbech 2003). The large lakes Boyes Sø and Amitsup Tasia are presumed to hold stationary stocks of Arctic char, but no information is available (Figure 12).

Two marine fish species use the subtidal zone for spawning in the springtime. This is the capelin (*Mallotus villosus*) and the lumpsucker (*Cyclopterus lumpus*). The spawning and fishing sites for these species were also mapped during the interview study (Olsvig & Mosbech 2003). No fishery for lumpsucker takes place in the coastal waters of Nuussuaq; therefore, knowledge on the spatial distribution of spawning sites is limited. Capelin is fished by local people and spawning takes place along several coastlines of the peninsula – mainly in the southeast and along the northern coast (Figure 11).

4.4 Vegetation

There is a rich flora on the Nuussuaq peninsula with more than 150 species of vascular plants. Many species have their northern or southern distribution limit on the peninsula and the variable geology – basalts, sediments or gneiss – creates a wide variation in edaphic conditions. About 35 localities have been studied thoroughly for vascular plants and as many as 141 species have been recorded in a single locality (Fredskild 1996). The following account is based on Fredskild (1996). An endemic species, the grass *Puccinellia rosencrantzii*, has its only known occurrence on the north coast of the peninsula and in the western part of the large central valley. Six other Greenlandic endemics are known from Nuussuaq (Table 4).

Table 4. Endemic Greenland vascular plants occurring on Nuussuaq peninsula (based on Fredskild 1996 and Bay 1999).

Species	No. of known sites in Nuussuaq
Antennaria affinis	5
Antennaria hansii	4
Antennaria intermedia	4
Festuca groenlandica	4
Potamogeton pusillus spp. groenlandicus	4
Pucinnellia groenlandica	4
Pucinnellia rosenkrantzii	4

Two other very rare plants in Greenland are known from the area: the grass of Parnassus *Parnassia kotzebuei* and the cinquefoil *Potentilla ranunculus* are known from 6 and 3 sites, respectively, on the peninsula, besides a few sites in South and Southeast Greenland (Fredskild 1996, Bay 1999). The distribution of collecting sites for the endemic species and these two rare species are shown in Figure 3.

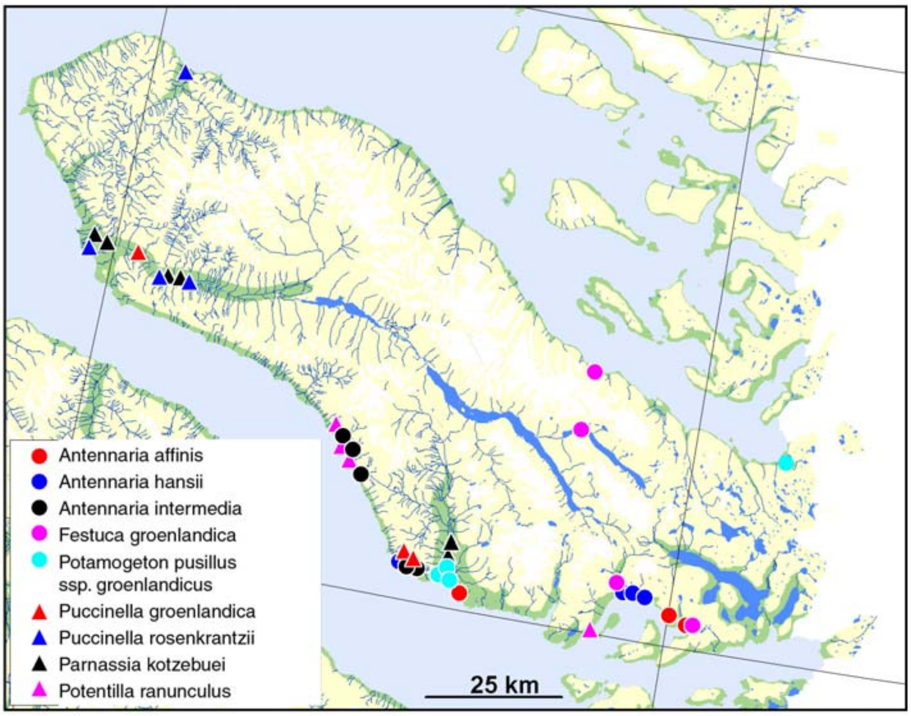


Figure 3. Distribution of collecting sites of some rare plant species on Nuussuaq peninsula. Modified from Fredskild (1996)

A group of species have, in addition to being widespread in East and/or North Greenland, a very isolated occurrence in West Greenland centred around the Nuussauaq peninsula: *Minuartia rossii* (one site), *Poa abbreviata* (6 sites), *Poa hartzii* (11 sites), *Poa pratensis* var. *colpoda* (6 sites), *Potentilla rubricaulis* (3 sites), *Puccinellia andersonii* (6 sites) and *Carex atrofusca* (7 sites) as the less common. Among the northern species with a southern limit in Nuussuaq or with a disjunct distribution in West Greenland the following are only known from a few sites: (*Draba fladnizensis* (1 site), *Ranunculus affinis* (1 site), *Toefieldia coccinea* (2 sites) and *Deschampsia pummel* (6 sites). Several species have their northern limit on the peninsula, a.o. *Juncus subtilis* (2 sites), *Poa flexusoa* (2 sites), *Trisetum triflorum* (3 sites), *Pyrola minor* (1 site) and *Rhodiola rosea* (1 site). Finally a group of species have their distribution in Greenland restricted to the central west Greenland region: *Pedicularis lanata* (common on Nuussauaq), *Braya liniaris* (2 sites), *Draba cana* (4 sites), *Luzula groenlandica* (2 sites) and *Primula stricta* (2 sites).

The vegetation in the moist lowland areas (mainly in the valley floors and the coastal slopes) is dominated by fens and grasslands. These are very wet just after snowmelt in May and June and during the summer at least the grasslands may more or less dry up. The moisture is to a large degree supplied from snow patches and the active layer above the permafrost melting. Salt marshes are extremely limited in extent and, as far as is known, occur only in the delta off the Affarsuaq valley. In the drier areas the vegetation is dominated by dwarf scrub heaths dominated by *Salix arctic*, *Dryas* or the heather *Cassiope tetragona*, depending on snow cover in winter. However, there are also extensive dry gravel plains almost without vegetation. Tall (> 0.5 m) *Salix* scrub occurs only very patchily in the southern part of the peninsula, e.g. the Saqqaq valley (Joensen & Preuss 1972), but may occur more abundantly further east.

A vegetation map has been produced from satellite images from 7 July 2001 and 12 July 2001 as well as from some field observations from 1996 and 2003 (NERI unpublished). The images were obtained within a 5-day period and have therefore been treated as one, after georegistration and atmospheric correction. Atmospheric and topographic correction was made using the ATCOR3 software (Richter 1997).

A normalised difference vegetation index (NDVI) is an index developed as an indicator of the level of greenness of the vegetation and is widely used for monitoring vegetation characteristics and differences. The NDVI is calculated as the difference in reflection between the near-infrared and the red spectral bands using the following equation (Rouse et al. 1973):

$$\frac{\sigma_{NIR} - \sigma_{RED}}{\sigma_{NIR} + \sigma_{RED}}$$

where σNIR is the reflection at the near-infrared wavelength (Landsat band 4) and σRED is the reflection at the red wavelength (Landsat band 3).

The images were analysed for greenness (NDVI) and surface moisture using a moisture index, II (the II, infrared index, is similar to the NDVI but uses band 5 and 4 from the Landsat ETM+ sensor to enhance areas with higher surface moisture (Jensen 2000)). Based on the analysis with information from the field observations it was possible to distinguish between six vegetation classes. The six classes were grouped after surface moisture from dry over moist to wet and after greenness from low greenness over medium to high greenness. The six classes are: 'Wet – High Greenness', 'Wet – Low Greenness', 'Moist – Medium Greenness', 'Dry – Medium Greenness', 'Dry – Low Greenness' and 'Sparsely Vegetated'. Areas with a NDVI below 0.1 were assumed to be non-vegetated.

Figure 4 shows an overview of Nuussuaq with the Landsat-7 ETM+ satellite image (combined from 7 and 12 July 2001) draped on the map. The image is a false colour composite of band 7, 4 and 2 in the red, green and blue colour channel, respectively. This enhances the contrast between vegetated and bare surfaces shown in green and red colours, respectively. Nuussuaq is dominated by the high mountain ranges north and south of the east-west oriented Aaffarsuaq Valley. The main part of the vegetation is located in the lowlands below 600 m. a.s.l., with the large forelands near the delta, the north slopes in the Aaffarsuaq Valley and the lower slopes of the Saqqaq Valley being the most densely vegetated. In the Aaffarsuaq Valley below 600 m the vegetation covers approximately 55% of the area. The eastern part of Nuussuaq (east of Saqqaq valley) is less vegetated than the western part (abundant red colours).

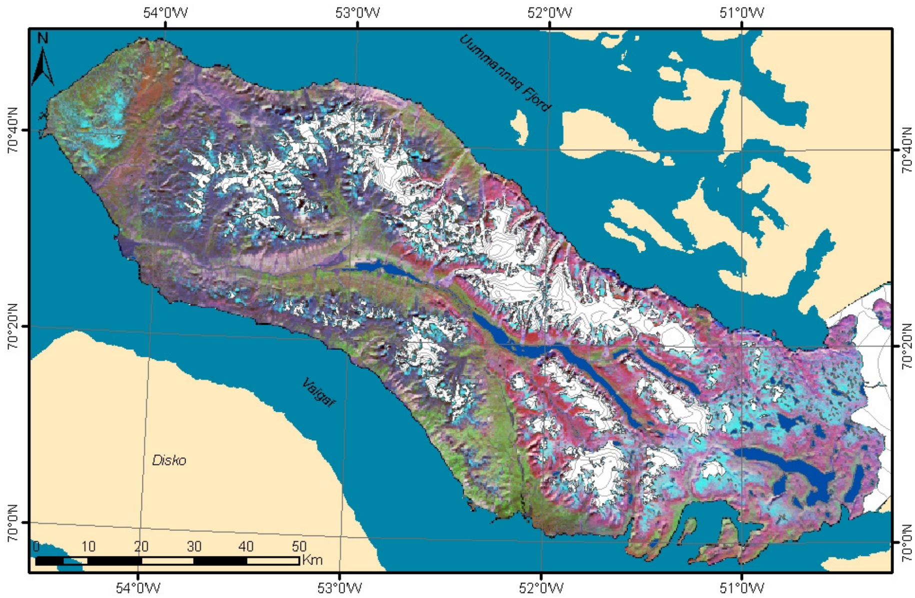


Figure 4. False-colour image of Nuussuaq combined from 7 and 12 July 2001. The image is a composite of Landsat-7 ETM+ band 7, 4 and 2 in the red, green and blue channels, respectively. This combination enhances vegetation in green colours, bare areas in brown and red, snow in light blue and water in darker blue colours (Coordinate system: UTM 22 N, WGS84, pixel size: 30 m).

Figures 5-7 show NDVI for Nuussuaq and two sub-areas of the Aaffarsuaq Valley. The two sub-areas show the coastal area (Figure 6) and the inland area from the Aaffarsuaq Valley to the large lake area in the centre of Nuussuaq (Figure 7). Three large areas with high greenness (orange to red colours) are found on Nuussuaq: the lowland part of northwest Nuussuaq, the inner part of the Aaffarsuaq Valley and the S-N oriented Saqqaq valley on the southern part of Nuussuaq (Figure 5). Two smaller areas (northeast slopes of Nuussuaq around 52°30′ W and the south facing slopes around 53°W) are also distinct on Figure 5. Values reach 0.7, which indicates very dense vegetation, mostly in the form of grasslands, luxuriant dwarf shrub heath, fens and some herb slopes. The NDVI image of the forelands at the mouth of the Aaffarsuaq Valley in Figure 6 is dominated by the southwest facing slopes north of the delta west of 54°W and several smaller areas south of the river, east of 54°W. The beginnings of an area with very dense vegetation on the north facing slopes of the Aaffarsuaq Valley is seen just east of 53°30′ W. These areas cover the slopes to within less than hundred meters from the river.

The high-NDVI north-facing slopes in the narrow valley dominate inland as shown in Figure 4. The south-facing slopes in the narrow valley are characterised by relatively low NDVIs below 0.3 with few areas of 0.4 or higher. This pattern changes somewhat when the valley broadens around 53°W and the south-facing slopes show larger areas with higher values of NDVI. The upper end of the smaller valley towards the north (Agat Dal) is characterised by very vigourous and dense vegetation (NDVI > 0.5) especially on the west facing slopes north of 70°30′ N. Field observations from the delta and lower valley system carried out in 1996 and 2003 were used to verify the vegetation map, but there were too few observations to perform an actual accuracy assessment. Furthermore, the collected field observations may not be representative for the eastern parts of Nuussuaq. This should be kept in mind when using the map. However, some major distinctions are possible from the grouping resulting in a possible vegetation type classification. Therefore, the 'Wet - High greenness' will probably be grassland and fens, especially in the coastal areas, turning into a luxuriant dwarf shrub heath and fens inland. Shrubs are also part of this class but mainly occur in the Saqqaq Valley. Differences between fen and grassland can normally be found through the *Eriophorum scheuchzeri* common in fens due to the high water flow, while *Eriophorum triste* is more dominant on the slightly drier grassland. Dwarf shrubs (*Salix arctica*) are more abundant in grassland, especially in tussocky areas. 'Moist - Medium greenness' will mostly be dwarf shrub heaths with a variety of species (*Salix arctica*, *Cassiope tetragona*, *Dryas* sp. etc.). The two dry groups are divided in medium greenness, probably with several types of dry grasslands, dry dwarf shrub heaths and lichen heaths, and low greenness, probably with steppe and fell field types. The 'Moist – Low greenness' will likely be snowbed areas and similar areas below large snow patches and areas related to streams and around lakes, while the last group 'Sparsely vegetated' is related to fell fields, gravel plains and abrasion plateaus with very little vegetation cover.

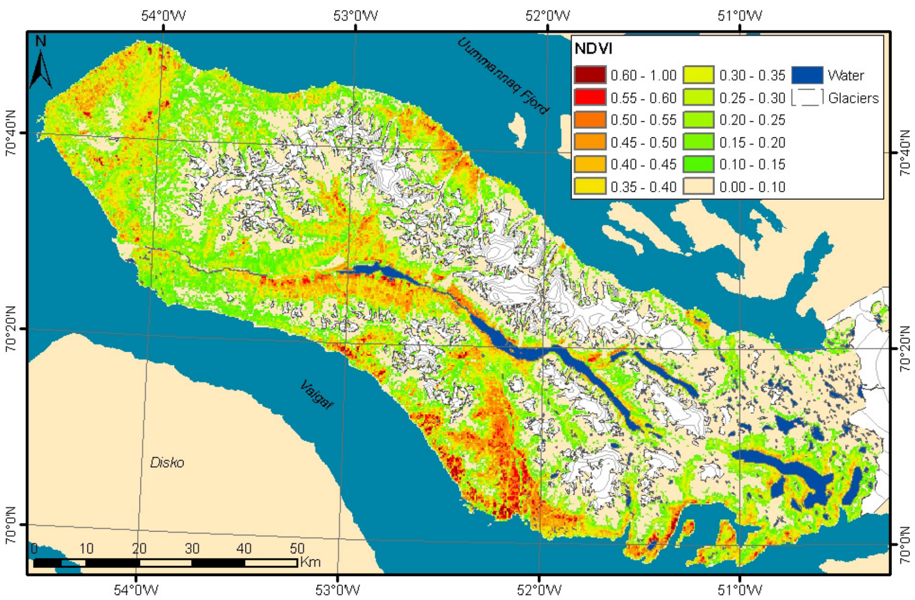


Figure 5. Normalised Difference Vegetation Index (NDVI) for Nuussuaq 7-12 July 2001. Light brown indicates no vegetation. NDVI scaled with green indicating sparse, low vegetation, yellow for intermediate growth and red for vigorous and dense vegetation (Coordinate system: UTM 22 N, WGS84, pixel size: 30 m).

Figure 6. Normalised Difference Vegetation Index (NDVI) for western part of Aaffarsuaq Valley on Nuussuaq 12 July 2001. Light brown indicates no vegetation. NDVI scaled with green indicating sparse, low vegetation, yellow for intermediate growth and red for vigorous and dense vegetation (Coordinate system: UTM 22 N, WGS84, pixel size: 30 m).

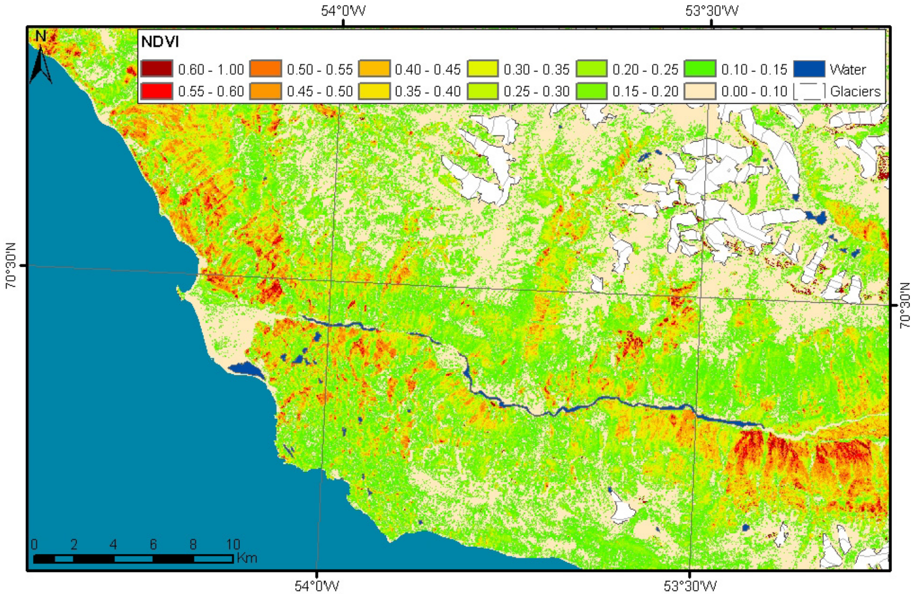


Figure 7. Normalised Difference Vegetation Index (NDVI) for eastern part of Aaffarsuaq Valley on Nuussuaq 12 July 2001. Light brown indicates no vegetation. NDVI scaled with green indicating sparse, low vegetation, yellow for intermediate growth and red for vigorous and dense vegetation (Coordinate system: UTM 22 N, WGS84, pixel size: 30 m).

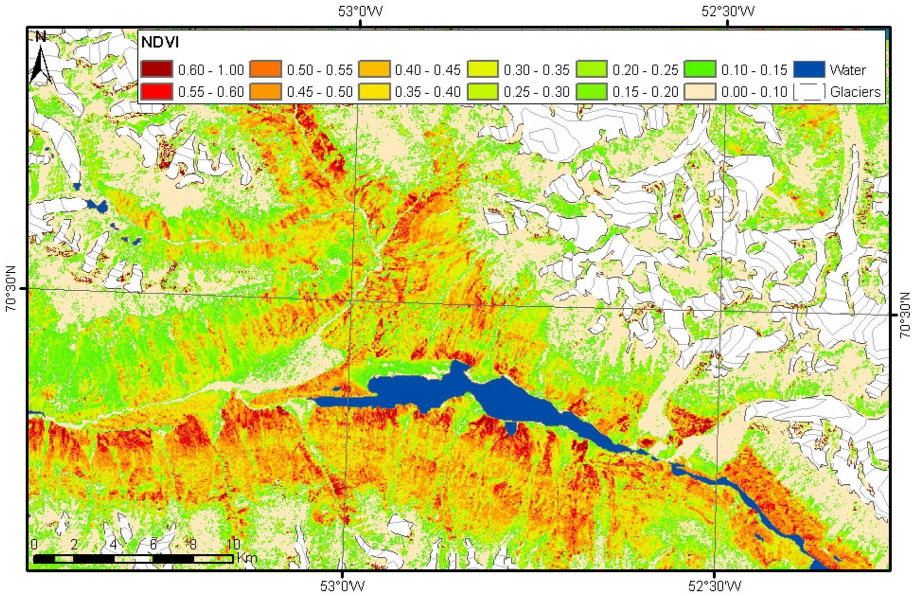


Figure 8 shows the land cover classes of Nuussuaq. 'Wet – High Greenness' is the most abundant type in Nuussuaq with a high degree of cover in the lowland and valley areas. The abundance of each of the six vegetation types for all of Nuussuaq, Aaffarsuaq Valley and Saqqaq is shown in Abundance (in %) of vegetation types in lowlands (< 600 m a.s.l.) of Nuussuaq.

More than half of the vegetated areas are covered by the wet and moist types with high and medium greenness (wet and luxuriant grassland, luxuriant dwarf shrub heath, fen or herb-slopes and moist dwarf shrub heath). The dwarf shrub heath type is most abundant in the Aaffarsuaq Valley, while the Saqqaq Valley has a higher abundance of the high greenness areas. The areas with less vegetation cover (snowbeds, *Dryas*-heaths, fell fields, etc) are abundant in the higher areas and eastern part of Nuussuaq indicated in Table 5 for the entire Nuussuaq peninsula.

Figure 8. Land cover map for Nuussuaq based on Landsat-7 ETM+ imagery from 7 and 12 July 2001.Vegetation is divided in six groups likely representing the following vegetation types: Moist - Medium greenness: Dwarf shrub heath with varying species. Wet - High greenness: Grassland and fens in the coastal areas and luxuriant dwarf shrub heath and fens in the inland. Wet - Low greenness: Snow and river bed vegetation. Dry - Medium greenness: Dry grasslands, steppe or fell fields. Dry - Low greenness: Fell fields. Sparsely Vegetated: Abrasion plateau and gravel plains with extremely sparse vegetation. In addition, non-vegetated areas are classified in ice-surrounded areas (nunataks) and other areas (Coordinate system: UTM 22 N, WGS84, pixel size: 30 m).

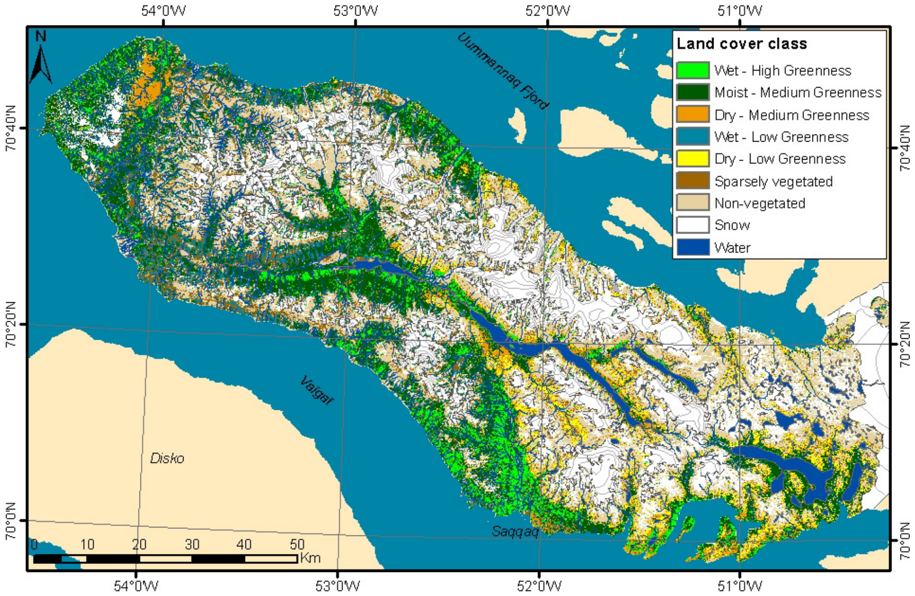


Table 5. Abundance (in %) of vegetation types in lowlands (< 600 m a.s.l.) of Nuussuaq.

	Nuussuaq	Aaffarsuaq Valley	Saqqaq Valley
Wet - High Greenness	10.9	12.4	31.0
Moist - Medium Greenness	40.2	64.0	45.0
Moist - Low Greenness	15.4	12.7	6.1
Dry - Medium Greenness	7.4	2.3	8.0
Wet - Low Greenness	8.6	1.7	4.8
Sparsely vegetated	17.5	7.0	5.2

The land cover in the central part of Nuussuaq (the Aaffarsuaq Valley and Saqqaq Valley) is shown in Figure 9. This is the most vegetated part of Nuussuaq – clearly visible on the figure with light green and dark green, respectively, for the high and medium greenness areas. The abrupt change in greenness between the western part and the eastern part of Nuussuaq is visible east of the Saqqaq Valley. The brown class represents the relatively large homogenous gravel plains. These may display some vegetation limited to a few scattered species. The light brown group covers the remainder of the non-vegetated areas apart from snow and water. This group typically comprises boulder and rocky outcrops that may have a cover of lichens, but also areas with frequent erosion from flooding (in the delta) or avalanches, or areas subjected to very late or perennial snow cover, especially at higher elevations.

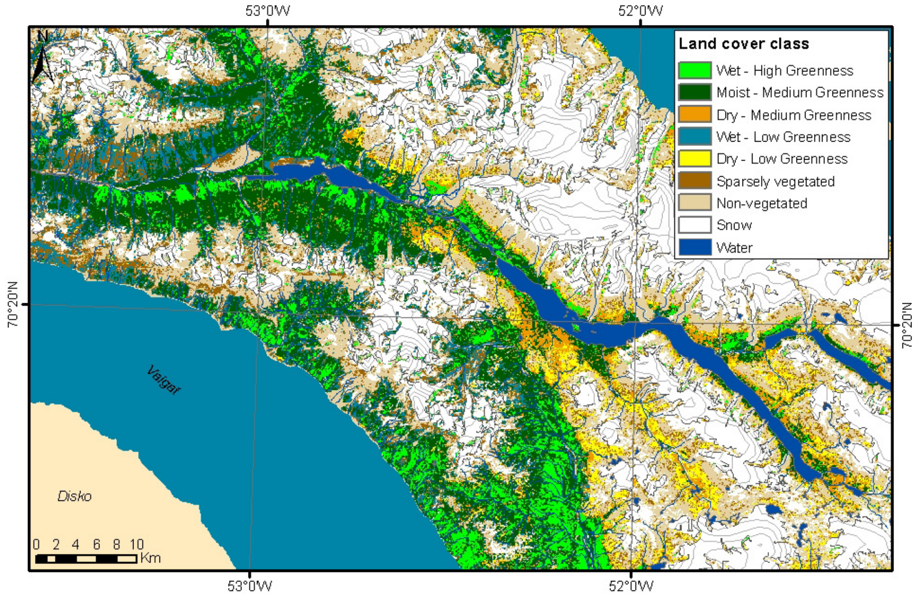


Figure 9. Land cover map for Aaffarsuaq and northern part of Saqqaq Valley on central Nuussuaq based on Landsat-7 ETM+ imagery from 12 July 2001.Vegetation is divided in five groups likely representing the following vegetation types: Moist - Medium greenness: Dwarf shrub heath with varying species. Wet - High greenness: Grassland and fens in the coastal areas and luxuriant dwarf shrub heath and fens in the inland. Wet - Low greenness: Snow and river bed vegetation. Dry - Medium greenness: Dry grasslands, steppe or fell fields. Dry – Low greenness: Fell fields. Sparsely Vegetated: Abrasion plateau and gravel plains with extremely sparse vegetation. In addition non-vegetated areas are classified in ice-surrounded areas (nunataks) and other areas (Coordinate system: UTM 22 N, WGS84, pixel size: 30 m).

4.5 Protected areas and conservation

No areas of the Nuussuaq peninsula are protected according to the Nature Conservation Act or are designated as bird protection areas (government regulation no. 1 of 21 January 2004 regarding protection of birds). No areas are designated according to international agreements such as the Ramsar Convention or UNESCO. But according to the Greenland bird conservation regulation, activities are regulated near seabird breeding colonies.

Furthermore the Bureau of Minerals and Petroleum has designated ‘areas important to wildlife’. One of these is situated in the Nuussuaq interior, in the central valley, in order to protect moulting concentrations of Greenland white-fronted geese. Exploration activities are regulated here. Furthermore, some of the seabird breeding colonies along the south coast are also included as ‘areas important to wildlife’ (Figure 10).

The international bird protection society, BirdLife International, has designated Important Bird Areas (IBA) in Greenland, but none are located on the Nuussuaq peninsula.

Table 6 lists species occurring on the Nuussuaq peninsula and included in the Greenland and the global redlists (IUCN 2007, Boertmann 2007).

Figure 10. Areas important to wildlife as designated by Bureau of Minerals and Petroleum. Black squares are seabird breeding colonies and the framed grey area is a moulting area for Greenland white-fronted geese.

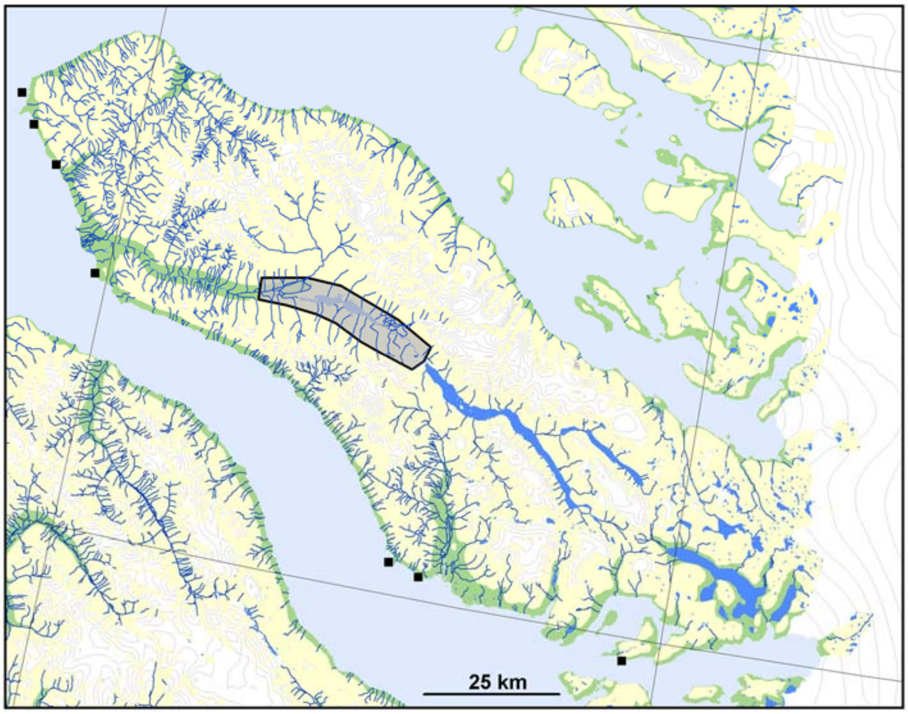


Table 6. Species or populations included on the Greenland and the global redlists and occurring in the Nuussuaq peninsula area.

Species/population	Status in Nuussuaq	Greenland red list category	Global red list category
Nuussuaq caribou *Rangifer tarandus* (Linnaeus, 1767)	Discrete population	VU	LC
Atlantic walrus *Odeobenus rosmarus* (Linnaeus, 1758)	Winter	EN	LR/lc
Harbour seal *Phoca vitulina* (Linnaeus, 1758)	Disappered	CR	LR/lc
Polar bear *Ursus maritimus* (Phipps, 1774)	Winter	VU	VU
Bowhead whale *Balaena mysticetus* (Linnaeus, 1758)	Winter	NT	EN
White whale *Delphinapterus leucas* (Pallas, 1776)	Winter	CR	VU
Narwhal *Monodon monoceros* (Linnaeus, 1758)	Winter	CR	DD
Great northern diver *Gavia immer* (Brünnich, 1764)	Breeder	NT	LC
Greenland white-fronted goose *Anser albifrons flavirostris* (Dalgety & Scott, 1948)	Breeder	EN	LC
Common eider *Somateria mollissima* (Linnaeus, 1758)	Breeder/Winter	VU	LC
Harlequin duck *Histrionicus histrionicus* (Linnaeus, 1758)	Breeder	NT	LC
Gyr falcon *Falco rusticolus* (Linnaeus, 1758)	Breeder/Winter	NT	LC
Kittiwake *Rissa tridactyla* (Linnaeus, 1758)	Breeder	VU	LC
Arctic tern *Sterna paradisaea* (Pontoppidan, 1763)	Breeder	NT	LC

LR/lc and LC = Least concern, NT = Near threatened, VU = Vulnerable, EN = Endangered, CR = Critically.

5 Local use

Local use of the coastal regions of Nuussuaq peninsula is described in the oil spill sensitivity atlas issued by NERI (Mosbech et al. 2004). The fisheries for specific species (Arctic char, lumpsucker and capelin) were investigated as a contribution to this atlas (Olsvig & Mosbech 2003). Prior to these studies, H.C. Petersen (1993a, b) described human use of local resources in two reports covering the Ilulissat and Uummannaq municipalities.

5.1 Fisheries

Fisheries in deeper marine waters include mainly northern shrimp (*Pandalus borealis*) and Greenland halibut (*Reinhardtius hippoglossoides*). The shrimp fisheries take place in the outer parts of the Vaigat and around Hareø. The Greenland halibut fisheries take place in the deep waters of the Torsukattak strait and off the north coast of the Nuussuaq peninsula. It is not likely that these fisheries will be affected by activities in the Nuussuaq area, although oil spilled from a blow-out and transported to the coast by a river or other water course could be an exception (cf. the strategic EIA of the Disko West area, Mosbech et al. 2007a).

Many other species of fish are caught in offshore waters and used locally or sold to local processing plants. They include: spotted wolffish (*Anachias minor*), redfish (*Sebastes spp*.), Atlantic halibut (*Hippoglossus hippoglossus*), Greenland shark (*Somniosus microcephalus*) and rough-headed grenadier (*Macrourus berglax*).

In the coastal waters of the Nuussuaq peninsula two species are important for the fisheries. Capelin (*Malotus villosus*) is fished mainly for private consumption in spring when they spawn in dense schools in the subtidal waters. Arctic char (*Salvelinus alpinus*) is fished both for private consumption and for sale at local markets (Figure 12). They are caught mainly with gill nets near the outlets of the rivers where they spawn. It is not possible to provide figures for the amounts of any of the species caught in the region. But the distribution of the fishing areas for capelin as recorded during the interviews in 2002 is presented in Figure 11.

Figure 11. Coastlines where capelin are known to spawn in spring and early summer (yellow) and where fisheries takes place (red). Based on data from an interview survey (Olsvig & Mosbech 2003).

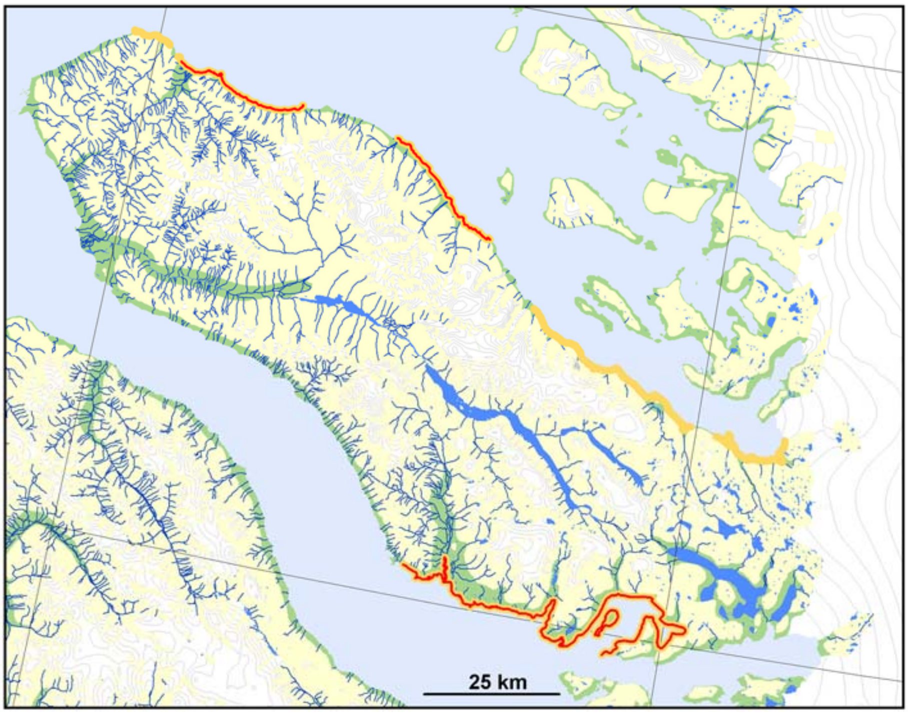
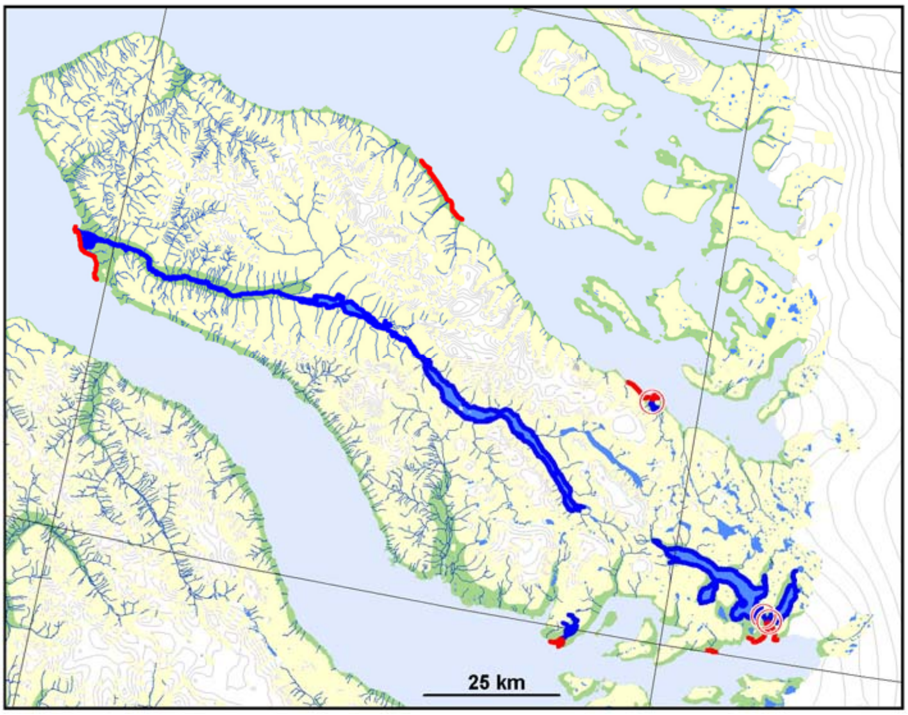


Figure 12. Coastline sections with Arctic char fishery (red) and rivers and lakes with occurrence of Arctic char: heavy blue based on interview survey (Olsvig & Mosbech 2003) and red circles based on H.C. Petersen (1983a, b).



5.2 Hunting

Hunting in the marine areas is aimed at marine mammals and seabirds. This activity is regulated by open seasons and quotas for many species, although no limits apply to seal hunting. The main quarry is harp seal (*Phoca groenlandica*) and hooded seal (*Cystophora cristata*) in the open water season and ringed seals (*Phoca hispida*) when ice is present. Walrus is hunted west of Hareø in winter. Also white whales and narwhals are important quarry. They are hunted mainly in late autumn (November) when migration takes place, and also in winter and spring. Niaqornat and the western tip of the Nuussuaq peninsula are important sites for the narwhal and white whale hunt in November, and Saqqaq is an important area for white whale hunt, also in November. Hunt for walrus, white whale and narwhal is now regulated by quotas and walrus hunting is also regulated in time.

Use of the inland areas in respect of hunting is not known in detail. Caribou is the most important quarry and the quota for the winter 2006/2007 was 420 animals distributed among hunters from the municipalities of Uummannaq, Ilulissat, Qeqertarsuaq and Qasigiannguit. Other quarry include ptarmigans, hares and foxes.

5.3 Tourism

Tourist activities on the Nuussuaq peninsula are limited. Boat trips are arranged from Ilulissat to Saqqaq, and hiking across the root of the peninsula is possible, although not an organised activity. From Uummannaq there are also boat trips to selected sites along the north coast.

6 Sensitive areas and species

A convenient way to apply sensitive elements in an analysis of conflicts with human activities is to designate Valued Ecological Components (VECs) as some kind of indicator of the sensitive environment of the area. These can be any part of the environment that is considered important by the proponent(s) of the activities in question, members of the public, scientists and government involved in the assessment process. Importance may be determined on the basis of cultural values or scientific concerns (definition from Natural Resources Canada). VECs can for example be species, habitats, local ecosystems etc., and they can be important in national and international nature conservation context, important to the local people in economic and cultural context, etc.

6.1 Species and their habitats

Mammals VECs include only caribou. The population is small and the native population is redlisted as vulnerable (VU). There is no knowledge on particularly sensitive habitats for this population, and information on habitat use, calving areas and winter foraging areas should be obtained.

Bird VECs include primarily the Greenland white-fronted goose. The population is small, it is decreasing and it is redlisted as endangered (EN). Particularly sensitive areas for this species in Greenland are spring staging habitats (late April to early May) and moulting areas (late June to early August), where large segments of the total population may occur in very restricted areas. Studies based on remote sensing of snow cover concluded that there are no important spring staging areas in the Nuussuaq peninsula (Glahder 1999, Glahder et al. 2002), but this conclusion may be re-assessed with climate change in mind. Moulting white-fronted geese were surveyed in 1992, 1995 and 2003 and the middle part of the central Valley Affarsuaq was identified as a very important moulting habitat for the species, with about 3% of the total population present in 1995 (Glahder 1999, Glahder et al. 2002). It was then among the five most important moulting habitats for the species in Greenland (Boertmann & Glahder 1999). The eastern part of the peninsula was only surveyed for moulting geese in 1992 and only superficially. This area should be surveyed more thoroughly. New data from the post-moulting period was collected in August 2007, but was not available for this assessment.

Other bird VECs includes gyr falcon, great northern diver, common eider, harlequin duck, kittiwake and Arctic tern. These species are all included in the Greenland redlist due to very small and/or decreasing populations.

The important habitats described above for Greenland white-fronted goose are VECs.

The seabird breeding colonies are also VECs. The majority of the colonies on the coasts of Nuussuaq are small and dominated by gulls. The most important colony is the large colony of kittiwakes at Naajaat southeast of

Qeqertaq (Figure 2). This is the largest kittiwake colony in the Disko Bay area and it is among the largest in Greenland. The seabird breeding colonies are occupied only in the breeding season usually from late may to early September.

Arctic char is a VEC because it is important to the subsistence and leisure fishery of local people. The rivers with spawning and wintering Arctic char are habitat VECs and are sensitive to activities redirecting or obstructing the water flow. These may obstruct the char as they move upstream to important spawning or wintering areas and may, under very unlucky circumstances, wipe out the entire population of a watercourse. Migratory char move from the freshwaters to the sea in early summer and back again to spawn and winter in late summer.

6.2 Flora

Several rare plants have been found on the Nuussuaq peninsula (cf. section 4.4 Vegetation). Their precise location cannot be established from the literature, as most have been reported as dots on a rather coarse map (cf. Figure 3). The precise locations, however, may be retrieved from the specimens in the herbarium of Botanical Museum in Copenhagen. At least the plant species mentioned in Table 4 are VECs and many more of the species mentioned in section 4.4 may potentially be VECs.

6.3 Vegetation

Vigorous and sensitive vegetation is found mainly in the wet terrain. Although wet terrain is sensitive, the vegetation in marshes and fens is usually able to regenerate rather quickly after being disturbed. Vegetation damage in dry terrain (dwarf scrub heaths such as *Cassiope*-heath) recovers usually much slower than in wet terrain and in some cases tracks may be visible in dry areas for decades or more.

The distribution of wet and dry vegetation types is known from the analysis of the satellite images (Figure 8 and 9), but knowledge of vegetation type is insufficient and should be improved by fieldwork.

6.4 Terrain

In general, Arctic wet terrain is very sensitive to human activities when the soil is not frozen. Impacts mainly stem from driving with heavy vehicles, which creates ruts and tracks in the soft terrain. The damage is mainly visual, but in some cases, particularly if the permafrost layer is disturbed, is widespread and progressive erosion and degradation of the permafrost layer may occur (thermokarst). A special feature of the permafrost in the Nuussuaq peninsula is the occurrence of pingos or mud volcanoes on the floor of the large valleys. Pingos are rare formations and they are particularly sensitive to damage from vehicles because they are without vegetation.

Wet terrain is mainly located on level or gently sloping areas along the coasts and in the valleys (Figure 8). The company Green Mining Ltd. in the Summer of 2007 experienced that the terrain was extremely difficult to evaluate with regard to moisture and capacity to carry heavy vehicles, as many areas had solifluctious soils and permafrost in some areas was close to the surface.

Coastal salt marshes represent a particularly sensitive habitat, which is found, according to information available for this assessment, only in the Affarsuaq River delta.

Dry terrain with loose sediments such as sand is sensitive to being driven on because tracks and ruts may initiate wind erosion.

7 Coastal sensitivity to oil spills

NERI has developed an oil spill sensitivity atlas of the West Greenland coastal zone between 68° and 72°N (Mosbech et al. 2004). From this it appears that much of the coast of Nuussuaq has a low or moderate sensitivity, but some coastline has a high or even extreme sensitivity to oil spills (Figure 13).

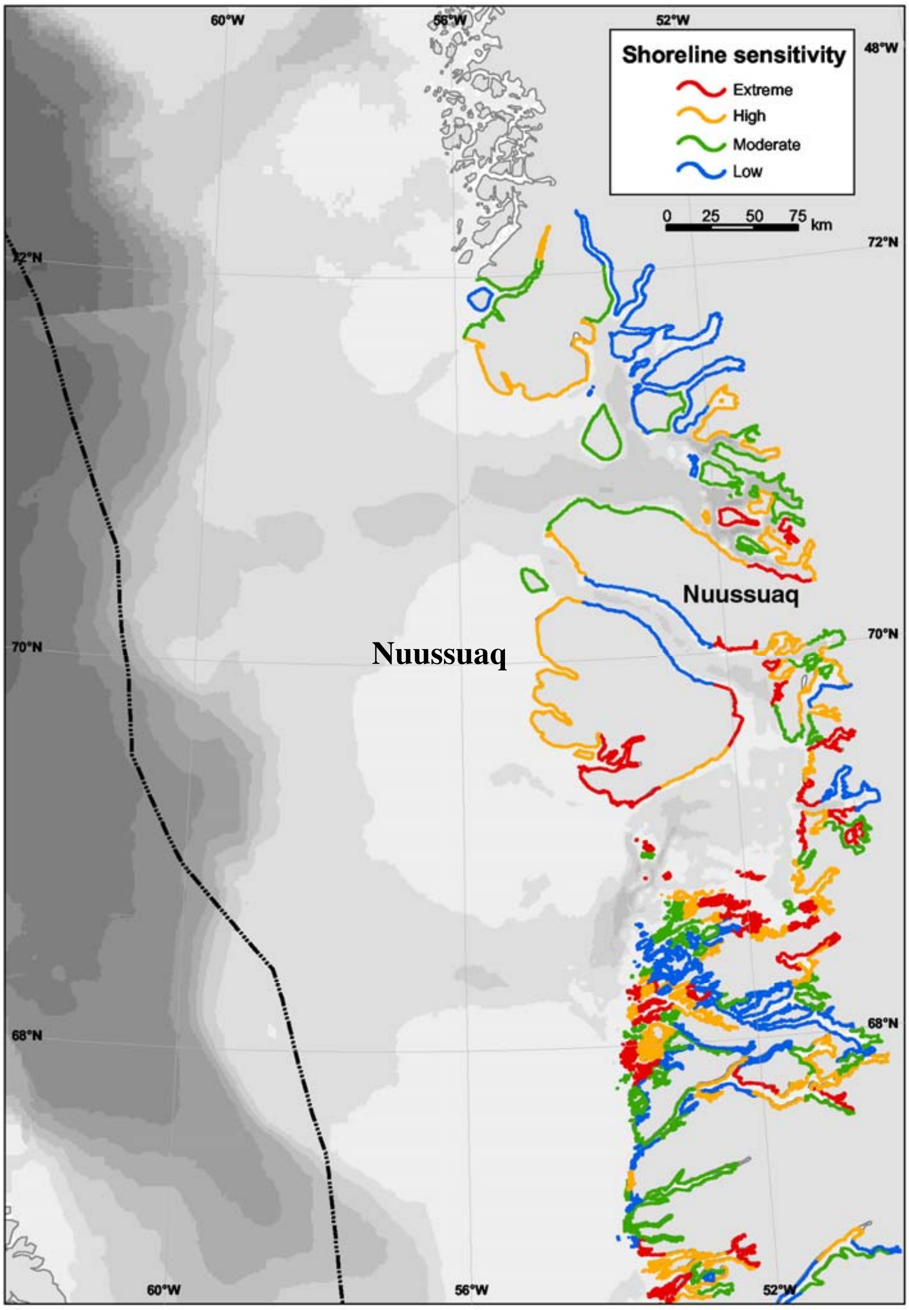


Figure 13. Environmental oil spill sensitivity of coast lines in central west Greenland. The coasts north of 72° N have not been classified. From the oil spill sensitivity atlas issued by NERI (Mosbech et al. 2004).

8 Status of pollution with mineral and hydrocarbon related substances

Apart from geological studies, the Nuussuaq peninsula has been very sparsely investigated for levels of trace elements and oil components.

8.1 The chemistry of the Nuussuaq peninsula

Sediments have been collected, analysed and reported by Loring and Asmund (1996).

Silty sediments adjacent to tertiary volcanic rocks contain higher concentrations of Cr, Ni, Cu and V than natural sediments from all other places in Greenland.

In the process of determining the natural levels of trace elements in marine sediments, it is important to delimitate the area where the sediments are composed of crushed tertiary volcanic rocks. Such an area is supposed to cover the entire Vaigat sound west of 52°W. There can furthermore be expected to be a correlation between these elements and oil components.

8.2 Animals and plants

There will probably be higher concentrations of Cr, Ni, Cu, V and oil components in animals and plants from the Nuussuaq peninsula compared to other non-basaltic areas in Greenland. But there are no documented investigations to prove this.

8.3 Samples in the DMU sample bank

Few studies of trace element and hydrocarbon levels in ecological components of the area (flora, fauna, sediments and water) have been published, but there are further relevant samples in the NERI Arctic sample bank. Table 7 lists the samples registered in the bank. Biological samples are mostly frozen, and sediment samples are dried.

Of these samples, only the 17 sediment samples close to Marraat have been collected in the area covered by this strategic environmental impact assessment. The other samples have been collected close to the area. They can be used only to estimate the environmental situation in general.

Table 7. Background samples from Nuussuaq and adjacent areas (between 69°N and 71°N of the Greenland west coast, excluding samples collected for the Maarmorilik mine project) kept in the DMU sample bank. The samples in the list covers all samples collected since 1980. Some may have been discarded or used up, but most of the samples still exist.

Species	No. of samples	Year of collection	Place
Molluscs			
Blue mussel	42	1994-2000	Kornprinsen Ejlande
Clam	24	1999-2000	Close to Kronprinsen Ejlande
Crustaceans			
Snow crab	23	1999	Between Godhavn and Kronprinsen Ejlande
Northern shrimp	11	1999	Uummannaq
Euphausiacean	14	1987	Godhavn, Disko
Fish			
Spotted wolffish	2	1999	Uummannaq
Greenland halibut	6	1999	Uummannaq
Long rough dab	20	1982	Mudderbugten, Disko
Shorthorn sculpin	75	1999-2000	Kronprinsen Ejlande
Marine mammals			
Minke whale	22	1998	West of Disko
Ringed seal	84	2001	Diskofjord and Mellemfjord
Algae			
Seaweed	2	1999	Kronprinsen Ejlande
Sediments			
Seabed sediment	17	2005	Close to Marraat, Nuussuaq
Seabed sediment	9	1987 and 1999	Disko Bay
Seabed sediment	34	1994	Kronprinsen Ejlande

8.4 Hydrocarbons

In relation to the strategic environmental impact assessment of the Disko West area, samples for TPH (Total Petroleum Hydrocarbons) and PAH (Polycyclic Aromatic Hydrocarbons) analysis were collected off the coast of the Maarraat area in the western part of the Nuussuaq peninsula (Mosbech et al. 2007b). These were analysed and compared with previous samples from Greenland. The conclusion was that sediments close to Nuussuaq (and Disko) have higher concentrations of PAH expressed in relation to organic matter content than sediments from the deep water along the West Greenland coast. But the study did not trace the oil seeps in the Marrat area. Observed levels of TPH and PAH were comparable to other Greenland and Arctic areas without oil seeps, and were lower than would be expected in an area with active oil seeps. The PAHs indicated that the source of the oil was fuel oil spills.

8.5 New samples

It is important to establish thorough baseline knowledge on metals and hydrocarbons before any future activities are initiated. New samples are therefore required, and a plan for sampling activities (particularly the sampling sites) should be prepared when the SEA is updated.

In particular the following samples are required:
From land habitats:

- Lichens from the area

From freshwater habitats:

- Sediments (GEUS are likely to have collected and analysed additional samples)

From marine habitats:

- Sediment samples covering the entire area and depths
- Seaweed and blue mussels from coastal stations
- Fish:
    - shorthorn sculpin from coastal stations
    - Greenland halibut, Atlantic cod, Greenland cod and spotted wolfish from deeper waters
- Northern shrimp, crabs, clams

9 Preliminary assessment of potential environmental impacts of mineral and hydrocarbon activities

Many environmental impacts are common to both mineral and hydrocarbon activities. These are described first, followed by impacts especially related to mineral activities and to hydrocarbon activities. The impacts can be divided into those which are related to species, habitats, landscapes, etc. (i.e. mainly disturbance and physical impacts) and those which are related to pollution from emissions (i.e. mainly chemical impacts).

9.1 Issues common to minerals and hydrocarbons

9.1.1 Disturbance to wildlife

Human activities in natural environments disturb animals to varying degrees. The level of disturbance depends on the species affected, the level of the activity, the affected species' ability to habituate, hunting (individuals in hunted populations are warier and shyer in relation to human activities than in populations that are not hunted). The impacts can lead to temporary or permanent displacement from important habitats and have the potential to cause population decreases.

On the Nuussuaq peninsula, lowland areas are very restricted. It is here that habitats important to wildlife are most likely found and, inevitably, it is also here that many activities associated with both the exploration and exploitation of minerals and hydrocarbons will take place, even though the mines or oil fields themselves will be placed in the mountainous regions. Therefore, the potential will be high for disturbance to wildlife on the Nuussuaq peninsula especially from large-scale operations.

Disturbance from exploration activities
Exploration activities (both mineral and hydrocarbon) have a high potential to disturb animals in large areas. Particularly, seismic surveys involved in the search for hydrocarbons may cover extensive areas. However, exploration activities are usually temporary and effects likewise are temporary and reversible. Even severe impacts e.g. a regional population decline will most likely be recovered if the affected population is not stressed by other negative impacts.

Disturbance conflicts with Nuussuaq VECs will primarily be with caribou and white-fronted geese, but also the seabird colonies along the coasts are at risk.

Caribou and disturbance
Studies on caribou behaviour have shown that the awareness and sensitivity to disturbance is highest during calving, which takes place 20 May to 20 June in the West Greenland population (Aastrup 2000) (Figure 14).

It was also shown that groups with calves were more aware than groups without calves (Figure 15). Calving grounds are often early snow-free areas that offer nutritious forage, which is highly important after the winter season. There is, however, no knowledge of such calving grounds on Nuussuaq.

Some of the calving areas in West Greenland are protected to allow the cows and their calves to reconstitute after the winter and the birth. The pregnant females have often been deprived of resources during the winter and it is important that calves as soon as possible can gain weight in order to be able to withstand climatic and other stress factors. Disturbances influence the energy balance negatively by increasing energy-demanding activity and decreasing food intake. This means that caribou that have experienced heavy disturbances during summer may have accumulated too little fat to survive the following winter. Similarly, a high level of disturbance during winter will lead to unnecessary depletion of energy and fat.

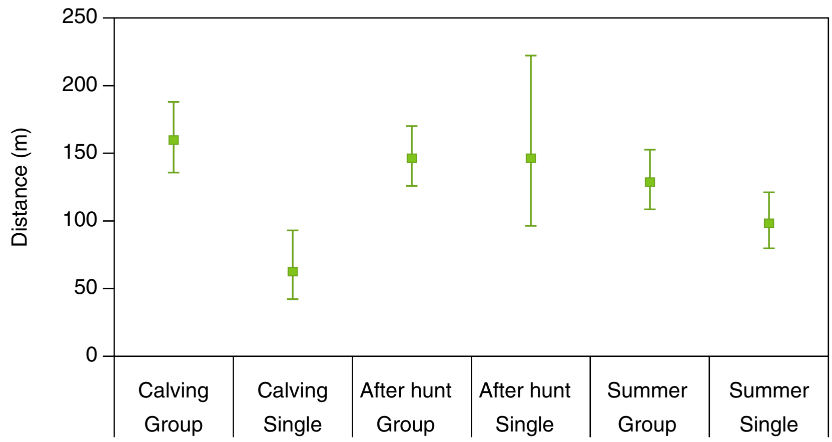


Figure 14. Flight threshold distance to walking people for caribou at different seasons in Greenland.

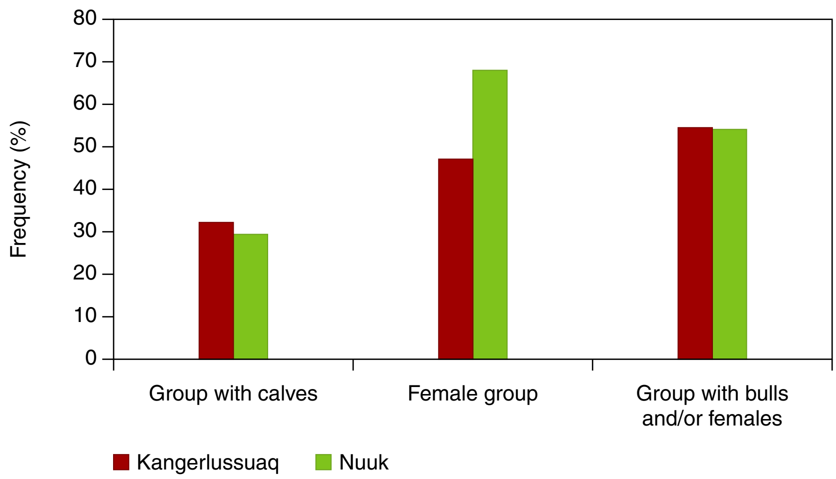


Figure 15. Frequency (%) of curiosity behaviour in groups with calves, female groups without calves and groups with both females and bulls (n=168).

It is generally agreed (e.g., Anon 1993) that calving areas deserve special protection during calving time. Some sex and age groups of caribou are able to habituate to some disturbances. Often it is seen that bulls forage close to roads and buildings, while pregnant females and new born calves stay away from such areas. Experiences from Alaska and Norway show that caribou tend to avoid areas along roads, power lines and tourist resorts (Cameron et al. 1992, Vistnes & Nellemann 2000).

The examples from Greenland confirm that caribou are more sensitive to disturbances during calving time and that groups with calves are more sensitive to disturbances than groups without calves.

The study quoted here was carried out on the large population in central West Greenland. It must be expected that the much smaller population in Nuussuaq is more sensitive to disturbance during calving season as well as during winter when the forage areas are restricted due to snow cover, because a larger proportion of the population may be disturbed by a single activity. The risk of effects on population level therefore is potentially higher. Careful planning and avoidance of activities in sensitive periods can mitigate and minimise the effects, but this requires detailed knowledge on the wintering areas and calving areas in the Nuussuaq peninsula, knowledge which is not to hand at the current time.

It is not possible to assess disturbance impacts on the caribou population, because the temporal and spatial distribution of population concentrations is not known.

Greenland white-fronted goose and disturbance

The geese arrive from their winter quarters in West Greenland during May, and the first three weeks the geese feed extensively in spring staging areas to fill up their fat depots. These depots are depleted during the spring migration. It is vital to the breeding geese to fill up their depots enabling them to produce and incubate their eggs and to defend their goslings.

In West Greenland there are at least ten major staging areas situated in the early ice-free area between 66°30’N and 69°N (Glahder 1999a, Glahder et al. 2002). These hold 80-85% of the total population. The geese stage at these areas for an average minimum period of 11.2 days in May (Glahder et al. 1999a). During staging the geese feed for nearly 80% of a diurnal period (Glahder et al. 1999b). Extensive disturbances at these major staging areas during the staging period will decrease the feeding period of the geese, which in turn can impact on the number of pairs that will be able to breed successfully. During the staging period the geese will stay alert when a walking person is closer than 700 m, and they will fly when a person is 200-500 m away. Fixed-wing aircraft at distances of 700-1000 m above ground will flush the geese (Glahder et al. 1999b). However no such staging areas have been found in the Nuussuaq peninsula.

The non-breeding and moulting geese constitute a sensitive segment of the population. During the moulting period in July the geese are tied to their moulting grounds for about a month. Therefore, a moulting ground must fulfil the geese’s requirements for sufficient feeding and refuge from predators (lakes or streams).

Undisturbed, the geese are able to maintain their body weight during moult (Hohman et al. 1992). This, in part, is because the geese save energy when they do not fly. Relative to the base energy consumption, flying demands 12.0 times more energy, while running takes 2.8 times more (Ravelin & LeFebvre 1967, Miller et al. 1994, Figure 16). Disturbance may therefore increase the need for food at the same time as the geese are scared away from optimal feeding grounds. When flight is regained, the geese build up their fat depots in August and September prior to the autumn migration.

Because moulting geese are only able to escape predators by running to refuge waters, the geese tend to stay rather close to these. It has been shown that white-fronted geese are particularly tied to open waters compared with another goose species occurring in East Greenland, and rarely move more then 30 m away (Figure 17).

Figure 16. Energy consumption at different goose behaviours. When geese are disturbed they use from 3 (run) to 12 (fly) times more energy than at rest.

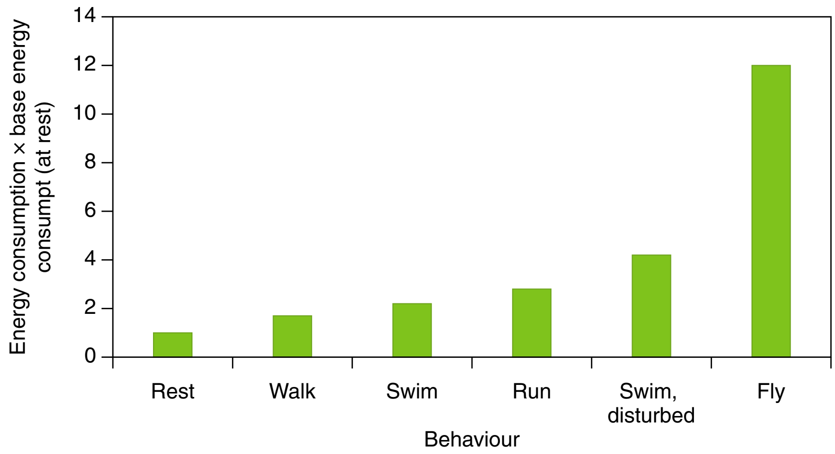
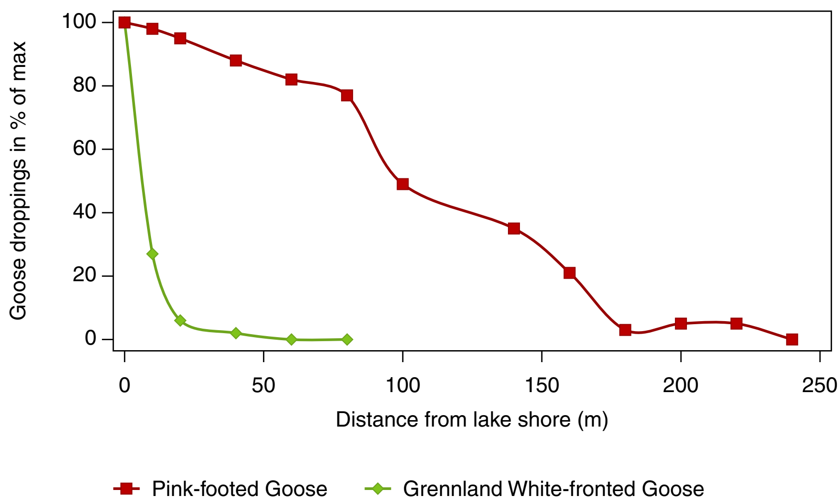


Figure 17. Two goose species' utilisation of their moulting ground expressed as goose droppings pr. m^2 in % of maximum numbers. Pink-footed Goose (Madsen & Mortensen 1987), Greenland White-fronted Goose (Glahder & Walsh 2007).



It has also been shown that a walking person made moulting geese alert at an average distance of 653 m and when the person walked on, the geese ran away at an average distance of 448 m (Glahder et al. 1999b, Glahder & Walsh 2007). In most cases the geese left their moulting habitat and ran several kilometers over land. The majority of flocks had returned to their moulting grounds three days after the scaring. Yet, one third of the flocks did not return until five days or more after the scare (Figure 18). During this time they may not have met their feeding demands and may consequently have lost weight.

The reaction of moulting pink-footed and barnacle geese to helicopters was studied in Jameson Land, East Greenland (Mosbech & Glahder 1991). The geese became alert to approaching helicopters at distances of between 2.5 and 9 km. The distances were dependant both on goose species and helicopter type (Table 8).

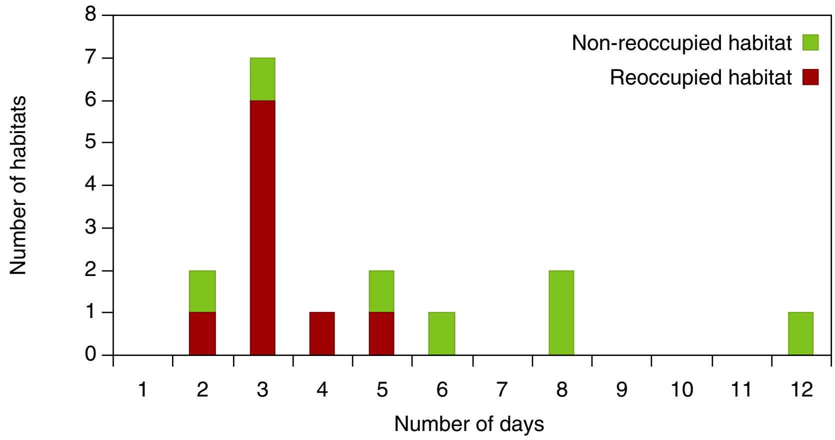


Figure 18. Number of days from disturbance of geese to either reoccupation of moulting habitat or end of moulting period. On average goose flocks stayed out of their moulting area for 4.6 days (SD=2.7, n=16). For habitats that were reoccupied the period lasted for 3.2 days (SD=1.0, n=9), while the average period for habitats not reoccupied during the moulting period was 6.3 days (SD=3.4, n=7).

Table 8. Distances (in km) to approaching helicopters where moulting geese showed alert reaction. Two goose species and two helicopter types were studied in Jameson Land, East Greenland.

Helicopter type	Pink-footed goose	Barnacle goose
Small, Bell 206	4.4 (1.0-6.5)	2.6 (0-5)
Large, Bell 212	8.7 (3-23)	9.1 (7.5-15)

Variations in distance (km) shown in brackets.

When the helicopters came closer to the geese they ran away as described for Greenland white-fronted geese being disturbed by a walking person. It was demonstrated that helicopter disturbance affected goose behaviour, so the time devoted to feeding decreased when disturbance increased (Figure 19). Anecdotal evidence indicates that the Greenland white-fronted geese are even more alert towards helicopters than the two species studied.

Greenland white-fronted geese breed in single pairs scattered with one km or more between nests. So, in most cases mineral exploration will affect only few nesting pairs during the breeding season. This is fortunate because disturbances during incubation would weaken the female goose if flushed too often; also, the eggs might be too cold and be exposed to predators such as Arctic foxes, ravens and glaucous gull.

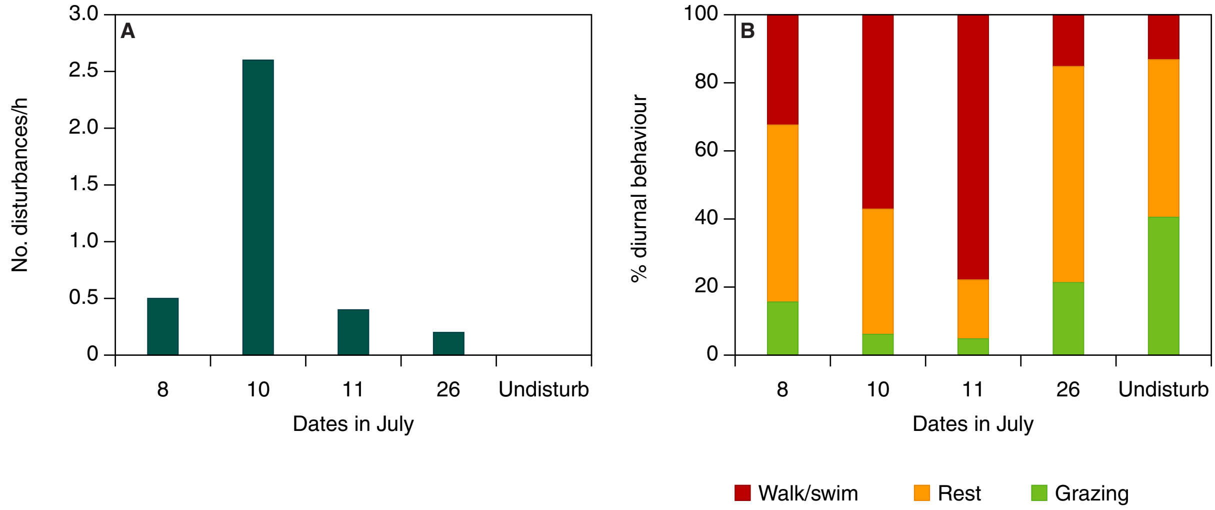


Figure 19. Moulting pink-footed geese decreased their feeding period when helicopter disturbance increased.

Geese are adapted to react to disturbances from natural factors such as predation by Arctic fox. Disturbances from human activities such as mineral exploration will be added to the natural disturbances. If these disturbances are extensive they can affect the geese's feeding abilities and also defence of their nests and goslings. Major activities can impact the whole population if they disturb important areas such as major spring staging areas, large breeding colonies, and major moulting grounds.

It is evident that there is a risk of disturbing significant proportions of the Greenland white-fronted goose population on the Nuussuaq peninsula. The population is particularly sensitive due to the declining trend in numbers. The major moulting area is designated as an 'area important to wildlife', in which mineral and hydrocarbon activities are regulated. There may be other similarly sensitive areas in the Nuussuaq region, particularly in the eastern part.

White-fronted geese have a concentration area in the central Affarsuaq Valley (Figure 10) where 3% of the total population occurred in the 1990s. If these birds were to be displaced to suboptimal habitats, they would risk increased competition form other geese, increased predation, slower growth of their flight feathers and eventual lower survival. The white-fronted goose population has no recovery potential due to its decreasing trend. For this reason, a worst case scenario ensuing from a disturbance event in the concentration area may comprise additional mortality, enhancing the decreasing trend.

Seabird breeding colonies and disturbance

Seabird colonies are particularly sensitive to disturbance from transport, such as sailing close by or helicopters flying at low levels, although some habituation may occur if the activities are regular and not harmful to the birds. The response of the colonial birds depends on the species. Gulls and cormorants are not particularly sensitive to disturbance; though in severe conditions may move their nest sites after a season with heavy disturbance. The most sensitive colonial seabird VEC will be the large kittiwake colony Naajaat (Figure 2). This colony holds 7-10% of the entire Greenland population. As the general population trend for kittiwakes in

Greenland is negative, the recovery potential is low and a worst case scenario for a disturbance event of this colony may be enforced decline of the total population.

Other birds and disturbance

Other bird VECs include gyr falcon, harlequin duck and great northern diver. However, it is not possible to assess potential impacts on these species as their distribution and density in the area is unknown.

Finally some of the coastal birds are VECs: Arctic tern and common eider. They breed on a number of the islands in the western part of the peninsula (Figure 2), and will not be impacted by activities on the mainland. But sailing, construction of terminals or other coastal facilities may affect the islands where they breed.

Disturbance from production activities

When exploration activities develop into production, the disturbance impacts will be less extensive in geographical extent, but will on the other hand be of long endurance. The impact will be limited to the surroundings of the infrastructure and the transport corridors, and be particularly heavy during construction and decommissioning.

Both Greenland white-fronted geese and caribou will be displaced from important habitats by disturbance from infrastructure placed in the near surroundings.

Placement of infrastructure and other footprints

Placement of structures, such as buildings, tank farms, machinery, gravel pads, deposits, roads, helipads, etc. including pits for extraction of gravel etc., eliminates habitats and kills vegetation. The main concern in this respect is the occurrence of rare plants with very limited distribution in the region (Figure 3). A large facility may completely cover a habitat for such species. Plants such as those listed in Table 4 are very vulnerable, and some of the endemics have so few known localities that more than 50% of them may be impacted by a single facility and the roads connecting the site to the coast.

Structures may also create barriers to migrating species. Caribou are sensitive to establishment of barriers in the terrain which may prevent access to important areas, and thereby potentially reduce the fitness of affected populations. Barriers can be pipelines, roads, transmission lines or even a large oil field/mining area covering the entire width of a valley etc. However, it is not possible to assess impacts from such as there is no knowledge available on seasonal migration routes. But a pipeline for example, crossing the central valley of the peninsula could potentially present a serious obstacle to migrating caribou, preventing them from reaching important habitats.

Arctic char migrate from the sea to rivers for spawning and wintering. The rivers they use are easily obstructed by constructions such as roads and dams, and the entire population may be hindered from reaching the wintering and spawning areas, and may eventually be wiped out. Recovery is probably very slow, because Arctic char are very faithful to the rivers they frequent.

Extensive activities such as large oilfields and large open mines, including the deposits for tailings and waste rock, may also cover substantial areas of lowland habitat, displacing breeding shorebirds and waterfowl. However, these species are widespread and common in Greenland (excl. white-fronted goose) and impacts will only be of local character.

Visual impacts

Driving in pristine Arctic areas involves a high risk of creating an extensive visual impact, in the form of tracks and ruts, particularly in moist lowland areas. The damage may be aggravated if the permafrost layer is affected and begins to thaw, resulting in thermokarst. Naturally, driving cannot be avoided, but it may be limited to strictly defined routes and eventually by the construction of real roads, preventing off-road driving.

Large deposits of waste rock, tailings, gravel pits or waste dumps may have a negative visual impact on the landscape.

Damage to vegetation

Arctic vegetation exists in a cold climate with a short growing season and access to water and nutrients is limited. Regeneration times are therefore very long, which means that tracks from driving or other activities may remain for decades or even centuries. Damage to vegetation can be caused either directly by the stripping of vegetation cover or by altering the physical characteristics of the soil.

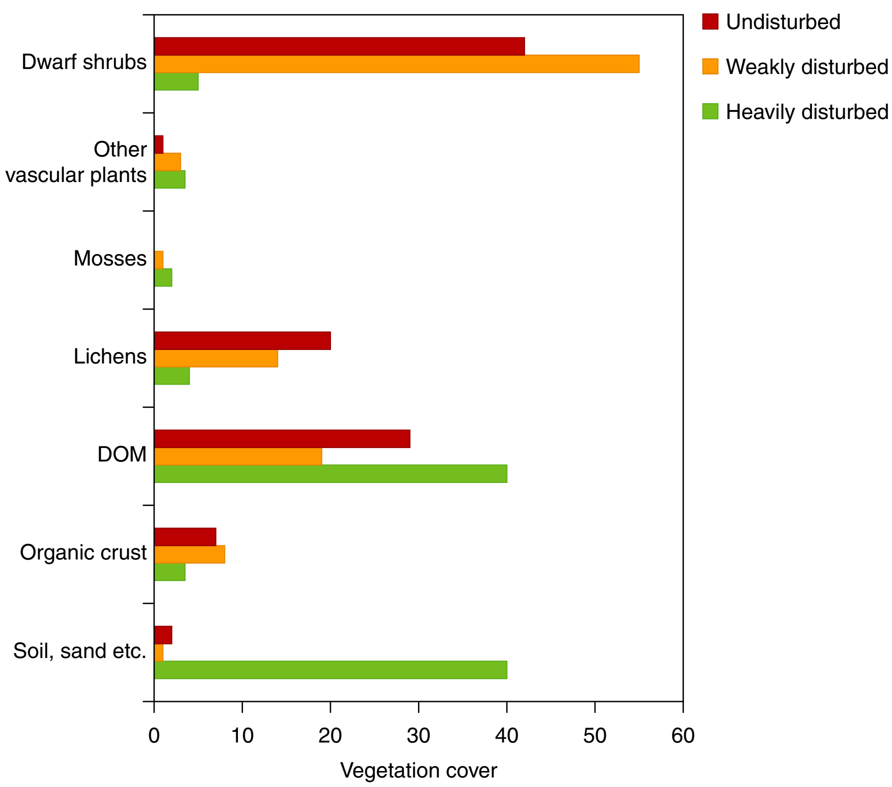


Figure 20. Changes in the vegetation cover in Greenland dwarf shrub heaths caused by driving related to seismic studies in Jameson Land, northeast Greenland. The percentage surface cover of dwarf shrubs, other vascular plants, mosses, lichens, dead organic matter (DOM), organic crust and exposed soil/sand etc. in undisturbed, weakly disturbed and heavily disturbed dwarf shrub heath in Jameson Land, East Greenland six years after the disturbance event (Strandberg 1997).

The figure illustrates that disturbed vegetation remains very different from the original vegetation even after a long recovery period. This is seen from the decrease in the cover of dwarf shrubs and lichens as well as the increase in the cover of the vascular plants that initiate a new succession of plant growth and in the amount of dead organic matter (DOM) and soil, sand, etc. (Figure 21).

Effects of driving and other destructive activities can be minimised by securing that: 1) the soil is well drained, 2) the soil is frozen to a minimum depth of 20 cm, 3) snow cover is at least 20 cm thick, and 4) a reconnaissance survey of a proposed driving route ensures that the most sensitive areas are protected.

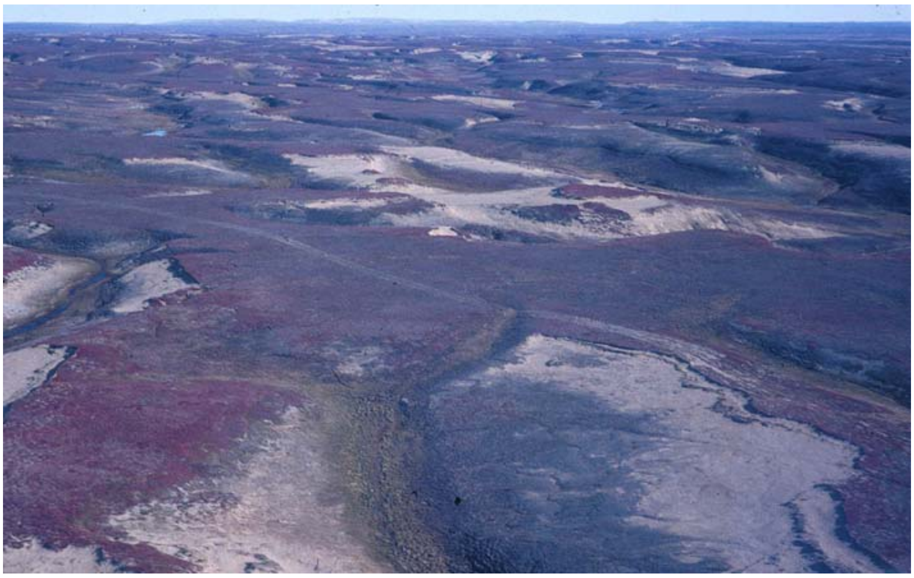


Figure 21. A track made in relation to seismic surveys in a *Cassiope* heath in Jameson Land, Northeast Greenland still visible approx 10 years after the driving event.

Tracks from driving are persistent in the landscape for many years. Therefore, uncontrolled driving will produce an accumulating visual effect on the landscape.

Vegetation is an important element in the landscape and, in addition, vegetation provides important forage for wildlife and reduces the risk of soil erosion.

Other impacts common to mineral and hydrocarbon activities

An important impact is the attraction of predators to human settlements. Especially foxes and large gulls may be attracted by human food resources, such as kitchen waste; and foxes moreover shelter among buildings and other constructions. Predator densities may therefore increase in the area surrounding a facility. This again will increase the predation risk for birds, particularly species that nest on ground (shorebirds, waterfowl). In this respect the VEC, the Greenland white-fronted goose again is vulnerable.

Freshwater for construction of ice roads, for use in camps and operations, will usually be taken from surface reservoirs, with the risk of changing water levels in wetlands and lakes. This, in turn, may change the character of lakes and rivers in cases where the level is so low that the water freeze to the bottom in winter. Many organisms are dependent on water in deep lakes and rivers for surviving the winter, e.g. Arctic char.

Wastewater

Wastewater from camps and buildings (grey- and blackwater) released to the environment may cause eutrophication if released untreated. The volume of wastewater from a large facility with a large number people has the potential to pollute extensive freshwater systems in the area.

Generally, impacts from wastewater can be mitigated by using the available technology and, if such technology is applied, impacts on the Nuussuaq peninsula can be minimised.

Drilling substances

Drilling takes place during exploration for minerals (diamond drilling) and during exploration for hydrocarbons. Many of the chemicals used during drilling are toxic to the environment; although the industry has gradually exchanged many of the toxic substances with less harmful substitutes. Effects from drilling components released from drilling processes will be local unless large amounts are released into freshwater systems where toxic substances can be transported widely. In general, it is possible to handle all the substances from drillings without any or with only minor effects on the environment.

Deposition of drilling mud and drill cuttings may be problematic to the environment, due to oil or chemical residues. When the oil drilling in Nuussuaq in 2006 was terminated, the drilling mud was deposited in the flaring pit and levelled. However, two years later it had subsided and this proceeded for at least eight more years, creating distinct hollows in the otherwise level surface.

Generally, impacts from drilling substances can be mitigated, and impacts are not expected in the Nuussuaq peninsula area.

Air emissions

Air pollution common to mineral and hydrocarbon activities relates to energy generation and the subsequent emission of combustion gasses. Unless an activity uses alternative energy sources, such as hydropower, combustion of fuel oil represents the main fuel source. Greenhouse gasses, e.g. NO_x, SO_2 and VOC (volatile organic components) are released to the air, and the impacts are well known. Besides the greenhouse effect, NO_x and SO_2 contribute to acidification which may impact the nutrient-poor habitats that have no neutralising capacity. This capacity has not been investigated in the region, but is expected to vary between areas where basalts are dominant and areas with sedimentary and gneissic overburden and bedrock. NO_x moreover has a nutrient effect which may impact the vegetation, cf. AMAP (2006) for more information.

The impacts of acidification from mining activities are well known from e.g. the smelters in the Kola Peninsula of Russia, where extensive areas are impacted by air pollution, including large areas where the vegetation has been completely destroyed (AMAP 2006).

Arctic haze is also a result of air pollution from combustion gasses (AMAP 2006). An area such as the Nuussuaq peninsula is prone to problems with Arctic haze, because of the valleys surrounded by very high mountains.

In this respect it should be stressed that Denmark (including Greenland) has ratified the UNECE LRTAB Protocol to Abate Acidification, Eutrophication and Ground-level Ozone (The Gothenburg protocol), an international agreement which aims at minimising and reducing air pollution.

9.2 Impacts related to the mineral activities

There are naturally high concentrations of chromium, nickel, copper and vanadium in the tertiary volcanic rocks of the Nuussuaq area. These elements and perhaps further elements could become the target for mineral prospecting end exploitation, and as recently as 2007 a company has been carrying out drillings in search of nickel.

The economically interesting elements will be present in characteristic minerals that will constitute only a minor fraction of the rocks in which they are present. It will probably be necessary to process the minerals on location to form one or more metal concentrates. The mineral concentrates can be exported or further treated (smelted) to obtain the metal. The following will not consider the activity of smelting, only the effects on nature and environment of mining, mineral dressing, and shipping of a mineral concentrate.

9.2.1 Waste rock

When mining occurs in an open quarry or in a closed underground mine some useless rock has to be mined in order to create space for the mining of the commercial ore. This rock, called waste rock, has to be deposited at some location, in an environmentally safe way.

Worldwide experience has shown that waste rock from metal mining often creates environmental problems due to acid drainage (see literature reference: ARD). This occurs when the waste rock contains pyrite or similar sulphur-containing minerals. These minerals will oxidise when they are wet and when they come into contact with air. Oxidation produces sulphuric acid, which in itself is an unwanted substance in the environment. But worse still, the sulphuric acid can dissolve many elements from the waste rock, thereby giving rise to heavy metal pollution. Elements like lead, zinc, copper, nickel, chromium, cadmium, and mercury can dissolve in sulphuric acid and spread to the environment and create unwanted pollution.

Sulphuric acid acting on the tertiary volcanic rocks of Nuussuaq will probably result in pollution from copper, chromium and nickel, as these elements are naturally enriched in marine sediments of the area (Loring and Asmund 1996)

Also acid-neutral waste rock can create environmental problems and the waste has to be disposed of in a safe way, so that it can be controlled and seepage water collected and, if necessary, treated.

The alpine terrain of Nuussuaq can make it difficult to find locations suitable for deposition of waste rock.

9.2.2 Tailings

Rarely, ore can be mined and exported directly. This, however, is the exception. Usually the mined ore has to be treated in some way in order to concentrate the economically interesting minerals. Today, flotation is the most common way to concentrate minerals, but also other techniques such as density separation or magnetic separation are used. They all result in a waste product, called tailings, composed of economically uninteresting fine crushed minerals. Tailings will often contain minerals or other compounds that are dangerous for the environment. Flotation requires the use of various chemicals, which may be toxic and which may be released with the tailings.

It is important to investigate the environmental properties of the tailings and use the investigations to design the best way of disposing of the tailings in a safe and environmentally acceptable way.

Unreactive tailings

If tailings have been shown to be chemically unreactive by means of thorough measurement and testing, it can be assumed that they are environmentally safe. From an environmental viewpoint, the tailings can then be disposed of in several ways, if the technical properties of the tailings are acceptable, e.g. as landfill.

Reactive tailings

However, in most cases tailings will contain one or more components that are harmful to the environment. In that case tailings have to be disposed of in a safe way, making it possible to control and treat the seepage, and in a way so that the tailings are permanently immobilised in all cases of weather and natural phenomena.

Lime is one of the most commonly used ingredients to be added to tailings or tailings seepage in order to neutralise acid and prevent spreading of dissolved heavy metals. A sedimentation pond is necessary in order to allow precipitation of the elements by the lime. All this requires a location suitable for construction of tailings dams, sedimentation pond(s), and controlled drainage. The alpine topography means that this might be the major problem for a new mine on the Nuussuaq peninsula.

Deposition of marine tailings

Marine deposition of tailings is a way to overcome problems associated with the construction of tailings facilities. The method will be economically attractive in most places in Greenland, and also in the Nuussuaq area. But the risk is always present that the tailings may have environmentally unwanted properties that were not discovered during the tests. Thus, the disposal of tailings will be particularly risky in a place such as Nuussuaq, where the marine topography does not have enclosed areas immediately suitable for marine disposal of tailings, and where possible disposal areas will always be connected directly with important fishing grounds, such as in the outer parts of Vaigat. An overview of the advantages and disadvantages of marine tailings disposal is provided by Ellis et al. (1982) and Ellis and Poling (1995). Impacts will, however, not be restricted to the disposal site, as the process creates a plume of suspended fine particles that will stay in the water column for several days and which may drift to a wide area.

Marine tailings disposal was used at the zinc and lead mine at Maarmorilik in the Uummannaq district in Greenland. This created unexpected and extensive environmental problems in the fjord at the mining site (Loring and Asmund 1987, Asmund and Johansen 1999).

For a strategic environmental impact assessment it is important to know the topography of the sea floor, the composition of the sediments and the currents, mainly in order to assess changes in composition of the sediment at the disposal site and the potential dispersal of harmful substances. As mentioned earlier, the sediment in Vaigat is naturally enriched in several elements including copper, chromium, vanadium and nickel.

The chemical problems with tailings are the same as those expected for waste rock. The most commonly observed environmental problem is that tailings that contain pyrite and other similar sulphur compounds oxidise, resulting in seepage of sulphuric acid.

9.2.3 Chemical impacts on flora and fauna

Mineral prospecting and extraction on the Nuussuaq peninsula will most probably be directed towards copper, chromium and nickel, which are the elements known to be enriched in the area. Even if this is not the case, the potential environmental problems are still likely to originate from one of these elements. It is therefore important to know the level of these elements in the different components of the Nuussuaq environment, a knowledge which to date is very limited.

After a mining operation has started, the levels of copper, chromium, nickel and other possible elements must be monitored in the environment around the mine. Suitable organisms are lichen (*Cetraria nivalis*), blue mussel, seaweed and shorthorn sculpin. Also commercially important species for the area must be monitored. Among these are shrimp, Greenland halibut, scallop and snow crab.

9.2.4 Auxiliary chemicals

Several different chemicals are used in mining and mineral dressing . For example, flotation might use a frother, an activator, a depressor and a collector, with e.g. cyanide often being used as a depressor. Cyanide is acutely toxic, but does not accumulate in the food web. Moreover, the explosives used in mining often contain ammonium nitrate, which can give rise to eutrofication of marine and fresh waters.

The Nuussuaq area is neither more nor less sensitive to auxiliary chemicals and nutrient enrichment than other areas in Greenland. Important fishing grounds primarily found in Vaigat must be protected against the negative effect of auxiliary chemicals. At the Titania mine in Norway where marine tailings disposal was used, a certain flotation chemical was adsorbed by fish living in the area, resulting in tainting (an unpleasant smell and taste from fish caught close to the tailings disposal area) (Miljøverndepartementet 1985).

9.3 Impacts related to hydrocarbon activities

'Produced water' is water from the oil bearing formation which is brought to the surface with the oil and gas. Water injected for increasing the oil or gas extraction may also form part of produced water. Produced water is usually saline, and includes oil residues and many other substances in small amounts, such as heavy metals and radionuclides. The amounts of produced water are large and in many offshore oil fields it is released into the sea. However zero-discharge solutions, which are now becoming standard in many oil fields, include re-injection of produced water back into the wells. This would probably also be the solution in a Nuussuaq oil field, because release into a nearby river would not be environmentally feasible.

9.3.1 Oil spills, chronic and accidental

Besides the oil in produced water, oil can also be released to the environment from many other chronic but small sources, such as runoff from deck and platforms, small operational spills, etc. From land-based facilities, these will contaminate the local area, but will not be spread to a wider area, unless oil is released into a river or lake.

Accidental oil spills

These may occur from blow-outs or from accidents during transportation and storage. Crude oil and fuel oil of different types may be spilled, and also spills of produced water containing salt may impact vegetation.

Impacts from an inland well blow-out will usually be limited to the local area around the site, because the tundra acts as a sponge. Impacts on vegetation will therefore occur in a relatively limited area compared to the impact areas of marine oil spills. The largest recorded impact area from an inland oil spill in Alaska covered 1700 m^2 (National Research Council 2003). However, if oil is spilled in freshwater systems much wider areas, including marine areas, may be affected by the oil. The large spills in Russia in 1994 affected approx. 70 km^2 in this way (National Research Council 2003).

Vegetation will be killed in affected areas and in freshwater systems; fauna, including stocks of Arctic char, are at risk of being wiped out. Vegetation recovery may take 10 years and even longer after spills of saline produced water, because the salt is not degradable.

Impacts from marine oil spills in the marine environment are described and assessed in the EIA covering the Disko West area (Mosbech et al. 2007a), and among the vulnerable species will be capelin and Arctic char (both VECs), as well as their habitats.

Hunting and fishing will be affected if coastal fish populations are reduced or if areas are closed as a consequence of an oil spill or pollution from tailings. If the caribou population is reduced, quotas will be similarly reduced or hunting will eventually be prohibited in order to restitute the population.

9.4 Summary of impact assessment

Exploration and exploitation activities have the potential to disturb two vulnerable populations (geese and caribou) at levels which may cause population decline. Some seabird breeding colonies may also be disturbed at levels which may cause temporary declines.

Extensive activities may cause visual impacts in landscapes, and impacts which may accumulate through time because of the persistence of terrain and vegetation damage. Activities in 1996, 2003 and 2007 have already created extensive visual impacts in the area in the form of tracks from different kinds of vehicles.

Large infrastructures, constructions and their transportation corridors have the potential to displace caribou and white-fronted geese from critical habitats, with the risk of causing population decline. They moreover may cover critical habitats for rare plants.

The main pollution risk from mines includes acid drainage from tailings and waste rock, and dust from open pits and transportation.

The main pollution risks from hydrocarbon activities are from the release of produced water, chronic oil spills and accidental oil spills.

Common to both mines and oil fields is extensive energy combustion resulting in release of greenhouse gasses, some of which also may impact the local environment by acidification, nutrient additions and arctic haze.

Hunting and fishery may be affected where accidents lead to pollution of the coastal environment, or if the caribou population is reduced.

10 Assessment of information status for the area, where are the data gaps?

10.1 Geese

In 1995, 1997 and 2000, spring staging habitats were surveyed in central West Greenland, and none were located on the Nuussuaq peninsula (Glahder 1999, Glahder et al. 2002). The spring staging habitats are crucial for the white-fronted geese, because the snow cover in early May, when the geese arrive from the winter quarters, is still extensive and limits feeding. Climate change may have altered the situation, making spring feeding areas available in the Nuussuaq area.

The most recent surveys of moulting geese (see above) indicated a decreasing trend in numbers of the white-fronted goose and an increase in numbers of Canada geese. The most recent survey was carried out in 2003, and the apparent trends should be studied further with a new survey, which also should include the easternmost valleys of the Nuussuaq peninsula, as these have never been surveyed for moulting geese. In August 2007 after the moulting season, a survey was carried out, but the data from this study have not been analysed and were not available for the present SEA. However, only parts of the goose habitats were surveyed and a full survey in the moulting season is still required.

10.2 Other birds

The information status on the birdlife of the Nuussuaq peninsula is generally good for the coasts and the western half of the inland. But there is no information available for the eastern area, especially the region including the large lakes Boyes Sø and Amitsup Tasia. Information can be collected on an ad hoc basis when other biological studies are carried out, but potentially impacted areas should be searched, particularly in relation to the VEC species, before any activities are initiated.

10.3 Mammals

The caribou survey in 2002 (Cuyler 2004) was not adequate for estimating the total population in the area. There is a need for more comprehensive studies including aerial surveys to map the habitat preferences and to estimate the population size.

Satellite tracking of a number of individuals will moreover give valuable information on annual movements and habitat use.

10.4 Other fauna

Invertebrates are not included in this account. Information, if needed, can possibly be retrieved from collections in the Zoological Museum, Copenhagen and from the scientific literature.

10.5 Vegetation

Overall knowledge on the flora is adequate, but more precise knowledge of habitats of species which require protection is lacking. This data gap should be filled before specific activities are initiated, and sites for activities should be searched for rare species.

Regarding vegetation, ground truthing is essential to verify the remote studies presented in this report. Moreover, a detailed ground truthing is essential in order to validate and improve the land cover maps. Currently, only the western part of the area is covered, and by too few observations, and there are no observations from the inland areas of the eastern part of the area.

Other flora/funga such as mosses, fungi and lichens are not treated in this account, but some information, if required, may be retrieved from comprehensive works covering the whole or parts of Greenland or from museum collections in for example the Botanical Museum, Copenhagen.

The most important data gaps to be filled as soon as possible are assessed to relate to:

- the occurrence of Greenland white-fronted geese: is the main moulting area in central Affarsuaq valley still as important as previously; are there other important moulting areas, particularly in the eastern part of the peninsula; are there important spring staging habitats; and distribution and numbers of breeding birds
- occurrence of caribou, population segregation, population numbers, annual movements, habitat use, identification of calving areas and important winter habitats
- gound truthing of satellite based vegetation maps
- general knowledge on flora and fauna, particularly in the lowlands.

10.6 Proposed studies to fill data gaps

10.6.1 Studies to be performed before opening the area for potential activities

The most immediate studies to be carried out will be the caribou and goose studies. A representative number of caribou, both the native and the introduced animals, should be equipped with satellite transmitters, and their movements tracked at least for one year, but if possible for longer. Another important task is to obtain an estimate of the numbers of caribou present in the area, and a survey – possibly aerial – should be carried out. These studies need at least two years to be completed.

An aerial survey for Greenland white-fronted geese should be carried out in July, when many birds are flightless and the breeding pairs have chicks. All lowland areas shall be covered. One year would be required for this study.

Ground truthing of satellite images will also be important. This shall be conducted in summer, and by a team of biologists who are moved between sites by helicopter. One year would be required for this study.

In combination with this ground truthing project a general survey for flora and fauna should be conducted. One year would be required for this study.

10.6.2 Studies to carry out before exploitation activities are initiated

Less immediate, but still important, will be the chemical baseline studies. A sample plan is required to be developed. Some of the samples can be collected on an ad hoc basis when other surveys are carried out. But a dedicated ship-based survey should be preformed along the coasts, perhaps supplemented by inland sampling from helicopter. Fieldwork can be performed during one summer.

Seabird breeding colonies on the shores of Nuussuaq peninsula and adjacent coasts should be surveyed before extensive activities are initiated. This can be carried out during one summer.

10.6.3 Studies to be carried out as part of specific EIAs

Information on rare plants and their habitats is not an immediate requirement, but should be collected before specific activities requiring placement of large structures are initiated.

In the same way rare inland fauna should also be searched for before activities are initiated.

Marine coastal fauna should be studied before large-scale oil exploitation activities are initiated and in case of marine deposition of tailings.

Bathymetric data from the surrounding waters will be needed in order to assess the possibilities for marine disposal of tailings in the case where a mine is established in the area.

11 Conclusions

Potential conflicts between mineral/hydrocarbon activities and biologically vulnerable elements of the Nuussuaq peninsula will mainly be restricted to the lowlands and the coasts.

There is a potential for impacting the caribou and Greenland white-fronted goose populations of the Nuussuaq peninsula by large-scale operations. Local stocks of Arctic char are sensitive to activities blocking their migration routes through rivers and creeks. Rare flora is moreover sensitive to placement of structures and oil spills.

There is a risk of increasing and accumulating visual impacts from driving operations in the area. Driving will be concentrated in the accessible areas, mainly in the valleys where vulnerable vegetation and terrain are found.

Mining and oil exploitation also impose a risk of pollution from waste rock, tailings, dust, produced water and added chemicals. However the emissions can be minimised and mitigated, and the risk for impacts is generally low but not excluded.

Emissions to the air from mining and oil production are generally considerable, and a large-scale oil production facility may increase the Greenland contribution to global levels significantly.

Many impacts can be mitigated by applying Best Available Technology (BAT) and Best Environmental Practices (BEP) in combination with strict regulation which limits activities in vulnerable areas and in vulnerable periods.

There is a general lack of biological knowledge concerning both strategic as well as specific environmental impact assessment in the area.

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